

A Preliminary Assessment of Vectors Associated with Stormwater Management Structures in the United States.

***Addendum**

CALIFORNIA DEPARTMENT OF HEALTH SERVICES

VECTOR-BORNE DISEASE SECTION

Gray Davis
Governor
State of California

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Grantland Johnson, Secretary
California Health and Human Services Agency



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Table of Contents

Background.....	2
Scope of the Addendum	3
Organization.....	4

States Investigated

Colorado.....	5
Maryland.....	8
Minnesota.....	15
New Jersey.....	19
Oregon.....	24
Texas.....	31
Virginia.....	36
Wisconsin.....	48
Conclusions.....	54

Appendices:

Appendix A: Contacted Agencies

Appendix B: Summary Report of a Visit to Portland, Oregon

Appendix C: Summary Report of a Visit to Austin, Texas

Appendix D: Maryland Department of Agriculture: report. "A preliminary survey for mosquito breeding in stormwater retention ponds in three Maryland counties"

Appendix E: Completed Questionnaires: See 09-Out-of-State-Survey, Appendix E

Background

In 1998, the California Department of Health Services, Vector-Borne Disease Section (VBDS) entered into a Memorandum of Understanding with the California Department of Transportation (Caltrans) to provide technical expertise regarding the production of vectors and vector-borne disease within its stormwater Best Management Practice (BMP) Retrofit Pilot Study. One of the tasks undertaken by VBDS for Caltrans was a study to determine the relative abundance and types of stormwater management structures in selected areas across the United States and assess their impact on local vector production and vector control activities. This study was essential because of the little available information on vector issues associated with these structures, despite the abundance of documentary evidence on the positive attributes of BMPs as stormwater management and water quality devices.

To establish a baseline evaluation, VBDS prepared a detailed questionnaire to solicit information from vector control agencies with regard to their experience with stormwater management structures. The objectives of the survey were to develop a better understanding of the vector issues associated with different structures, factors affecting vector production within structures, and the solutions used to correct them when necessary. On January 11, 2000, 338 surveys were mailed out to vector control agencies nationwide. Exactly 105 agencies participated in the study, of which 72 (69%) provided feedback on vectors associated with local structures. The responses from these agencies provided a preliminary assessment of the potential public health risks involved with the construction of structures such as the Caltrans BMPs, addressed factors that encouraged vector production, and summarized the views of vector control agencies on these issues.

Scope of the Addendum

The report generated by VBDS based on responses to the questionnaire revealed that vectors are associated with stormwater management structures nationwide. This confirmed that vector production noted within Caltrans BMPs is not unique to southern California or to the specific BMP technologies implemented by Caltrans as part of their stormwater Best Management Practice (BMP) Retrofit Pilot Study. Instead, it demonstrates that opportunistic vector species will utilize a variety of habitats that provide them with food and shelter, resulting in increased human health threats.

Stormwater runoff is a relatively new and rapidly growing field of interest in the United States. Most states have begun implementing structural and non-structural BMPs to comply with local, state, and federal regulations regarding stormwater runoff management and water quality. Many states outside of California have years or decades of valuable experience working with BMPs. Unfortunately, there is a general lack of inter-agency communication, particularly between agencies involved with water issues and those involved with vector issues. Information gained from different agencies could be used to improve upon BMP structures planned for use in California and would provide some background useful for establishing or improving upon inter-agency relationships.

Eight states were selected for more detailed investigations into vector / BMP related issues. This addendum study includes a variety of agencies at different levels of government, and with different overall objectives, to provide a more rounded, non-biased view of the vector / BMP relationship. VBDS used a slightly different approach to conducting this addendum study. Rather than mailing out questionnaires and waiting for responses, agencies were first actively searched out using the Internet and local area contacts, then contacted by phone. The biggest challenge was locating the most qualified person(s) within an agency to discuss issues relevant to the scope of this project. Once found, the person(s) was contacted directly by phone. During phone conversations, VBDS staff took detailed notes and solicited that a questionnaire be completed. For consistency, the same questionnaire that was used in the original study

was used in this addendum study. Using this process, VBDS obtained more information from agencies than in the original study, and nearly all questionnaires were completed and returned. Over 45 agencies were contacted and are included in the following addendum report.

Organization

Agencies contacted as part of this addendum study had a variety of different objectives and the contact person's knowledge of BMP / vector issues varied widely. As a result, the following report is divided into 8 sub-sections by state and each contacted agency within a state is treated separately. A general summary is provided for each of the eight states that discusses briefly the responsibilities of the contacted agencies, their involvement with BMPs and/or vectors, and Internet addresses if available. Following the general summary, are details of the phone conversations between VBDS and each contacted agency within the state, beginning with state agencies, followed by successive levels of government. It should be noted that local agencies that actually design and implement BMPs usually had more knowledge of BMP design, function, maintenance, and associated vector issues than did higher level regulatory agencies.

Six reference appendices are included in this report, including: A) as list of contacted agencies, B) a report summarizing VBDS' visit to Portland, Oregon, C) a report summarizing VBDS' visit to Austin, Texas, D) a report prepared by the Maryland Department of Agriculture, Mosquito Control, entitled "A preliminary survey for mosquito breeding in stormwater retention ponds in three Maryland counties" (upon request), E) a manual prepared by the New Jersey Department of Environmental Protection, State Mosquito Control Commission, entitled "Best management practices for mosquito control and freshwater wetlands management" (upon request), and F) copies of questionnaires returned by contacted agencies (upon request). It should also be noted that written information provided on returned questionnaires may contain additional information not discussed during the phone conversations.

COLORADO

Summary. VBDS investigated BMP / vector issues in Colorado, with emphasis in and around the city of Denver. Vector control in the city of Denver is conducted primarily by the City and County of Denver, Department of Environmental Health, Division of Animal Control (<http://www.denvergov.org/dephome.asp?depid=42>). However, the City and County of Denver, Community Planning and Development Agency, Neighborhood Inspection Services (<http://www.denvergov.org/dephome.asp?depid=710>) occasionally conducts some vector control on an "as needed" basis. The Denver suburb areas to the north of the city contract out some of their mosquito control to a private organization called *Colorado Mosquito Control, Inc.* (CMC) (<http://www.comosquitocontrol.com/>). CMC also conducts all of the mosquito control in Jefferson County, to the west of Denver County. Commerce City is part of the Denver-metropolitan area and has a vector control program within the Tri-County Health Department (<http://www.tchd.org/>) that covers Adams, Arapahoe, and Douglas Counties, to the north, east, and south of Denver County, respectively. The Colorado Department of Public Health and Environment, Disease Control & Environmental Epidemiology Division (<http://www.cdphe.state.co.us/dc/dceedhom.asp>) is not directly involved with mosquito control in the state, but will act as a consultant to local agencies when requested.

Colorado Department of Public Health and Environment. A state epidemiologist in the Disease Control & Environmental Epidemiology Division, was contacted by phone in October/November of 2000. He was familiar with mosquito problems, but was not the right contact for the interests of VBDS and Caltrans. On January 31, 2001, the Vector Control Program manager for the state was contacted by phone.

Summary of the phone conversation with The Vector Control Program manager. The State vector control program is strictly a consulting agency that will assist and advise local agencies as needed. For example, they will conduct field surveys to determine mosquito species present and advise on abatement procedures. However,

the State does not conduct any type of mosquito control. They do however conduct plague surveys in conjunction with the Center for Disease Control, located in Fort Collins. The state of Colorado has a very de-centralized program and municipalities and/or counties will decide whether or not to implement a vector control program. In many cases, mosquito control is contracted out (i.e. Colorado Mosquito Control, Inc.) because it is more economical. In other cases, Parks and Recreation, who conduct mosquito control on a very local basis, sometimes run rural areas. It was suggested that VBDS contact the City and County of Denver, Community Planning and Development Agency, Neighborhood Inspection Services because they are involved with various aspects of pest control in Denver.

Denver Community Planning and Development Agency. The Neighborhood Inspection Services, was contacted by phone on February 16, 2001 and again briefly on February 26, 2001.

Summary of the phone conversation. Our contact occasionally does some vector control on an "as needed" basis in pond / riparian habitats. He suggested that people involved with a committee called Urban Drainage, within his agency, be contacted for more information on stormwater issues.

Denver Department of Environmental Health. The field inspector for the Division of Animal Control, Vector Control, was contacted by phone on January 31, 2001.

Summary of the phone conversation. Vector surveillance and control is only conducted on city owned lands. Some of the typical sites inspected and treated include creek beds, river edges, culverts, detention ponds, and areas of new development. Our contact was aware of water management structures, old and new. She stated that many structures were built in and around the massive urban development areas near the new Denver International Airport. She mentioned that mosquitoes are regularly associated with many of the structures, and that many of the structures do not drain at the rate they were designed to, resulting in additional problems.

Colorado Mosquito Control, Inc. The president of the Colorado Mosquito Control (CMC), was contacted by phone on February 1, 2001. CMC participated in the original VBDS study back in June 2000.

Summary of the phone conversation. CMC is a privately owned municipal contractor that works in different areas of the state. In the Denver area, they have some contracts in the suburban areas, north of Denver, that are not part of the city of Denver; however, CMC will work on both privately owned and city owned lands depending on the contract. CMC will not do maintenance on any of the canals, ponds, etc. that they abate for mosquitoes. Our contact noted that maintenance of these structures has been lacking severely and that in many cases, abatement that is performed for many consecutive months could be avoided if the structures were maintained regularly, allowing the water to drain as intended in the original designs. He also mentioned that thick cattail growth as well as trash and debris accumulation frequently prevents proper drainage of canals. Dense stands of cattails also create mosquito problems in wet ponds.

Tri-County Health Department. The supervisor of the Vector Control Program, was contacted by phone on February 26, 2001.

Summary of phone conversation. Urban stormwater runoff in the Tri-County area is captured mainly by urban or commercial-based ponds. These structures are designed to drain rapidly, in approximately 72 hours. However, our contact mentioned that after the first few storms, structures tend to clog with sediment and trash and form ponds of water. This water then becomes overgrown with thick mats of filamentous algae and duckweed. He has seen larvae along the edges of these ponds, but believes that the water becomes so clogged with vegetation that it may occasionally exclude mosquito larvae.

The aesthetics of urban pond structures are frequently enhanced by building parks around them. Ponds are supposed to be maintained by homeowners associations. Interestingly, our contact's experience, many people don't even know what the purpose of the pond is.

MARYLAND

Summary. VBDS investigated BMP / vector issues in the state of Maryland. The Maryland Department of Agriculture, Office of Plant Industries and Pest Management, Mosquito Control Section (<http://www.mda.state.md.us>) is responsible for administering and implementing mosquito control throughout the state of Maryland. Frederick County Health Department, Environmental Health Services, Mosquito Program (<http://www.frederickhealth.org/environment/community.htm>) conducts basic mosquito surveillance and monitoring and is one of many counties that contracts with the State for mosquito control. Calvert County is one of the few Counties in Maryland that have an operational mosquito control program (<http://www.co.cal.md.us/services/mosquito.htm>).

There is a collaborative plan among three state agencies to respond to West Nile Virus: Maryland Department of Agriculture (MDA), Maryland Department of Health and Mental Hygiene (DHMH), and the Maryland Department of Natural Resources (MDNR). More information on this group can be found on the Internet (<http://www.dhmh.state.md.us/publ-rel/html/westnile.htm>). The overall head of the cooperative group agreement is the Secretary of Health and Mental Hygiene, Georges Benjamin. Each agency in this group has a role: 1) MDA does mosquito collections and identifications, dead bird pick ups, and sends pools of specimens to DHMH, virology lab, for testing, 2) DHMH screens pools of specimens received from MDA for Eastern Equine Encephalitis, Saint Louis Encephalitis, and West Nile Virus, and operate the West Nile Virus and dead bird hotline for public information, and 3) MDNR coordinates wildlife disease work and takes care of animal trapping for disease monitoring and surveillance when necessary.

The Maryland Department of the Environment (<http://www.mde.state.md.us>) heads up NPDES related issues and is responsible for preparing the state BMP manual. The 2000 Maryland Stormwater Design Manual that MDE prepared, as well as publications related to non-point source pollution are available on the Internet (<http://www.mde.state.md.us/environment/wma/stormwatermanual/>).

The Maryland Department of Transportation is divided up into several Administrations. The State Highway Administration (<http://www.sha.state.md.us/>) is responsible for construction and maintenance of many of the BMP structures throughout the state.

Maryland Department of Agriculture. Cyrus Lesser, the head of the Mosquito Control Section in the Office of Plant Industries and Pest Management, was contacted by phone on April 10, 2001. Later the same day, Mike Cantwell, the Maryland Department of Agriculture (MDA) regional entomologist for western Maryland was also contacted by phone. He handles the contracts with individual counties within the state and is more closely involved with field situations.

Summary of the phone conversation with Cyrus Lesser. The MDA is responsible for surveillance, control, recommendations, and mosquito identifications for almost every county in the state. There are only a few counties with their own operational mosquito control programs; other counties all contract with the State for mosquito control. Cyrus Lesser has been trying repeatedly to get vector issues recognized by the Maryland Department of Environment (MDE), which regulates all state BMP guidelines and is responsible for preparing the State manual. Although MDA had sent numerous written requests to MDE for consideration of mosquito issue "verbage" (for the State manual) within the construction of BMPs, MDA has had no response from MDE. The 2000 BMP guidelines manual produced by MDE mentions mosquitoes briefly and states that they are an insignificant factor within water quality ponds.

Cyrus Lesser mentioned that Maryland Department of Transportation is the primary state agency that builds structural BMPs. He also mentioned that many of the BMP designs are becoming progressively worse in terms of providing more suitable mosquito larval habitat. Many water quality ponds are being built with very shallow sections (swampy) with planted aquatic and semi-aquatic plant species. These structures hold water for weeks, even in summer, and act like natural vernal pools or emergent wetlands and are a very large source of mosquitoes. Dry detention basins and bioswales are also frequent sources of mosquitoes in Maryland, particularly

floodwater species. Permanent wet ponds that are stocked with mosquito fish have been the least problematic in terms of mosquito production.

Developers of new subdivisions in Maryland are required to built stormwater runoff ponds. The developer then is supposed to be responsible for upkeep and maintenance of these structures. However, when MDA finds mosquitoes associated with these ponds, there is often a lot of "finger pointing" when attempting to determine who is responsible for their maintenance. Many ponds have fallen in to disrepair with thick, uncontrolled vegetation (including trees) that makes vector surveillance and control efforts difficult and reduces the ability of the pond to serve its original purpose for water quality.

Cyrus Lesser suggested that VBDS also contact Ken Pensyl, the Environmental Program Manager for MDE, and Wilson Freeland, the supervisor of the Calvert County Mosquito Control Program, for additional information.

One last bit of interesting information that Cyrus Lesser mentioned was that there is a group called the Council of Governments (COG) that includes Washington D.C., northern Virginia, and adjoining areas of Maryland. This group coordinates on issues such as West Nile Virus that are of mutual importance to all three areas.

Summary of the phone conversation with Mike Cantwell. Mike Cantwell is a regional entomologist for MDA and handles individual county contracts within western Maryland. For example, when a county health department or other agency reports a mosquito problem, the appropriate regional section of MDA will respond and assess the severity of the situation.

Ponds in western Maryland are owned by the County they reside in, or by developers. Most permanent ponds appear to be maintained, whereas problems with vector production are most often encountered with dry detention ponds. The majority of pond structures in the State are dry detention, designed to drain quickly (approximately 5-10 days). Unfortunately, many are built into areas with clay soils that do not infiltrate well, and perform worse as sediments accumulate. These structures mainly produce floodwater mosquitoes including species of *Aedes* and *Psorophora*, but can also provide habitat for *Culex* and *Anopheles* mosquitoes in those that hold water for longer

periods of time. Problem sites are inspected every other week, or monthly, and treated with Altosid when necessary.

BMP structures are frequently built in the center of community developments and most are relatively new, less than 20 years old. Many are constructed with steep sides with no access for equipment, and in many cases, trees, shrubs, and other plants will grow freely impairing access to the site and making mosquito control efforts extremely difficult.

Calvert County Mosquito Control Program. Wilson Freeland, the supervisor of the Mosquito Control Program, was contacted by phone on April 10, 2001.

Summary of the phone conversation with Wilson Freeland. Calvert County is one of the only counties in the State with their own mosquito control program. There are several different types of BMPs in Calvert County including artificial/mitigated wetlands, dry ponds, wet ponds, and infiltration basins. Many BMP structures are built in "open space" areas of subdivisions. The entire community is laid out so that stormwater ends up in the BMP, usually in a "recreational area". Unfortunately, most of these ponds have no provisions for maintenance.

Wetlands are most apt to produce large numbers of mosquitoes because they are built with very shallow water and are planted heavily with native grasses and plants. *Anopheles* mosquitoes capable of transmitting malaria are abundant in these wetland habitats. There have been several cases of malaria in Maryland that appear to have been contracted locally (Information on these cases may be available in the AMCA archives).

Maryland has a native mosquito fish species, *Gambusia holbroki*. State regulations dictate that it can only be introduced into stormwater structures for mosquito control, not into natural waterways. These fish are stocked into most permanent ponds providing excellent mosquito control year-round (winters in Maryland are usually not cold enough to kill off fish populations). Wilson Freeland would like to have shallow wetland "swamps" constructed with a deep area or zone where mosquito fish could survive when water levels drop. One of his main concerns is that the wetlands dry up periodically preventing the survival of mosquitofish with their current design. Wilson

Freeland has been unsuccessful in convincing developers, the County, or the State involved in BMP construction to include a deep area within the constructed wetlands that would support mosquito fish.

Frederick County Health Department. Tom Mohler, the manager of the Environmental Health Services, Mosquito Program, was contacted by phone on April 10, 2001.

Summary of the phone conversation with Tom Mohler. The Frederick County Health Department does not run its own independent mosquito control program. Like most county programs in the state of Maryland, Frederic County contracts with the Maryland Department of Agriculture (MDA) for mosquito control. The County is only responsible for vector monitoring, surveillance, and collection of samples for identification. When problem sites are discovered, MDA is contacted to identify collected samples, evaluate the severity of the vector problem, and determine if treatment is necessary.

In Frederick County "bio-retention" ponds are most apt to produce mosquitoes in large numbers. These are permanent water structures that are planted heavily and serve as sedimentation and water quality ponds. Tom Mohler has investigated different types of ponds and has found that dry detention ponds that drain approximately within a week do not produce mosquitoes. He did mention however, that the mosquito problems in the inland counties of Maryland such as his are small compared to those encountered along the coastal regions. Tom Mohler suggested that VBDS contact Mike Cantwell, the Maryland Department of Agriculture regional entomologist for western Maryland who would be able to provide me with more information on MDA fieldwork.

Maryland Department of Environment. Stewart Comstock, with the Water Management Administration, Non-Point Source Program, was contacted by phone on April 16, 2001.

Summary of the phone conversation with Stewart Comstock. Stewart Comstock is one of the key people responsible for writing the Maryland Stormwater Design Manual. Maryland is moving away from stormwater ponds and structural practices in

general. Instead, the Maryland Department of Environment (MDE) is encouraging pollution prevention, particularly through the use and implementation of non-structural BMPs: open section roadways (with no curb) that allow even runoff, roof downspouts that direct runoff into vegetated areas of yards rather than to curb drains, small on-lot filtration devices, landscaping and vegetation appropriate for reducing runoff into streets, natural conservation areas that receive and disperse flow are just some of the examples. If structures must be built, then MDE is encouraging them to be designed "smart from the start". Designs should keep maintenance needs to a minimum and should be least conducive to vector production. Dry designs used for volume reduction or water quality should drain down very rapidly (1-3 days).

The governor of Maryland had made a statement recently about BMPs, stating that if designed properly, water quality ponds and wetlands did not pose significant mosquito problems because of natural enemies of mosquito immatures present in the system. Stewart Comstock was aware of mosquito issues, particularly associated with structures that drain slowly and do not support natural predators, especially facilities with vegetated bottoms. However, there has been no active mosquito monitoring within MDE. Stewart did mention that there is a reference on mosquito production in constructed wetlands that MDE had used as a reference written by the Center for Watershed Protection. The article is available on the web through the Stormwater Manager's Resource Center (SMRC), Reference Library at (http://www.stormwatercenter.net/Database_Files/Publications_Database_1Page311.html).

Maryland Department of Transportation. Steve Udzinski, an engineer with the State Highway Administration, Highway Hydraulics Division, was contacted by phone on April 10, 2001.

Summary of the phone conversation with Steve Udzinski. Steve Udzinski mentioned that some Caltrans people had recently been over to visit the Maryland Department of Transportation (MDOT) regarding BMP structures and costs. MDOT has had some complaints regarding mosquito production in BMP structures, but Steve Udzinski was not aware of the extent of the problem. MDOT designs and builds

structures based on the characteristics of the project and on their intended purpose. For example, those used for water volume reduction are structures such as extended detention basins, whereas those used for water quality improvement are structures such as shallow marshes or permanent ponds.

Steve Udzinski mentioned that many BMP designs look good on paper, but once built, do not necessarily work well in the field. MDOT is becoming more sensitive and aware of biological factors within BMP designs. The basic philosophy of MDOT regarding new BMPs is that they should be built to address both water quality and wildlife issues. Because MDOT does not have their own BMP manual, they have adopted the new manual written by the Maryland Department of Environment. MDOT also obtains their NPDES permits through the Maryland Department of Environment.

MINNESOTA

Summary. VBDS investigated BMP / vector issues in Minnesota, with particular interest in the metropolitan area of Minneapolis-St. Paul. Mosquito control for the entire metropolitan area of Minneapolis-St. Paul is conducted by the Metropolitan Mosquito Control District (<http://www.mmcd.org>).

The state of Minnesota, Department of Natural Resources, Waters Division (<http://www.dnr.state.mn.us/waters/>), is a regulatory entity that manages the state's water resources. The Minnesota Pollution Control Agency (<http://www.pca.state.mn.us/netscape.shtml>) is the state agency responsible for protecting Minnesota's air, water and land resources from the effects of pollution. They handle all NPDES permits in the state and are responsible for preparing the BMP manual.

The Minnesota Department of Transportation, Office of Environmental Services (<http://www.dot.state.mn.us/environment/>) deals with storm water management.

Minnesota Department of Natural Resources. John Stine, of the Waters Division, was contacted by phone on April 23, 2001.

Summary of the phone conversation with John Stine. John Stine is employed by the Minnesota Department of Natural Resources (DNR), Waters, the group within Minnesota DNR that is responsible for implementing the federal EPA Clean Water Act for the state. Minnesota DNR Waters is basically a regulatory agency that does some ecological studies, but is generally not directly involved with BMPs. John Stine suggested that VBDS contact Doug Norris, also with Minnesota DNR, but in the Ecological Services Division. In addition, he suggested VBDS contact either Don Jakes or Mark Gernes (a wetland specialist) of the Minnesota Pollution Control Agency, the agency responsible for handling all state NPDES permits, for more information regarding BMPs.

Minnesota Pollution Control Agency. Don Jakes, the supervisor of Unit 2, Community and Area-wide Programs Section, Policy and Planning Division, was contacted by phone on April 27, 2001.

Summary of the phone conversation with Don Jakes. The Minnesota Pollution Control Agency (PCA) handles all NPDES permits for the state and is responsible for preparing the BMP manual for the state. Don Jakes was not aware of any mosquito issues associated with structural BMPs, but mentioned that the Minnesota PCA has a program to remove old tires from the state, in part to reduce mosquito habitats.

Minnesota Department of Transportation. Bruce Johnson, with the Minnesota DOT, Office of Environmental Services, Stormwater Management, was contacted by phone on April 23, 2001. He pointed referred VBDS to Leo Holm, the section director, and Greg Busacker, an aquatic biologist. Greg Busacker was contacted by phone on April 23, 2001. Dwayne Stenlund, a soil ecologist, was contacted by phone on April 24, 2001 as a result of Greg Busacker's recommendation.

Summary of the conversation with Greg Busacker. Greg Busacker is an aquatic biologist employed by the Office of Environmental Services, Environmental Process Unit (EPU), which works on projects statewide. The EPU makes sure that construction districts follow state rules and regulations, and they act as liaisons between regulatory agencies regarding water and environmental issues.

The Minnesota Pollution Control Agency recently completed a very extensive BMP manual that has been adopted by Minnesota DOT. The Minnesota DOT has implemented a number of different BMP structures including sand filters, infiltration devices, and ponds, but prefer to utilize pond systems as often as possible. Mosquito production within Minnesota DOT BMP structures have not been considered; however, they have received complaints of mosquitoes associated with some of their structures from citizens.

In general, maintenance of Minnesota DOT BMP structures is poorly budgeted for. Structures are built without a budget for regular maintenance resulting in "crisis maintenance", which is essentially a response to public complaints or if Minnesota DOT

personnel happen to notice a problem while on the job. The issue of BMP maintenance seems to be a problem for the Minnesota DOT.

Summary of the conversation with Dwayne Stenlund. Dwayne Stenlund also works with the Office of Environmental Services as a soil ecologist. He was very passionate on the issue of stormwater BMP structures and had a wealth of knowledge on the subject.

Dwayne Stedlund believes that temporary ponds create more of a mosquito problem in Minnesota than do permanent ponds because of the lack of natural predators in temporary systems. In Minnesota, non-native fish such as *Gambusia affinis* can not be stocked into natural waterways. As a result, many "leaky" BMP ponds that drain into natural waterways cannot be stocked with mosquito fish. Dwayne Stenlund would like to see better use of natural, existing ecosystems for water quality purposes rather than the construction of federally mandated ponds and other BMP structures.

Dwayne Stenlund emphasized that there is a serious need for maintenance plans for all BMP structures. Most designs get lost over time and incoming crews frequently do not properly maintain structures because they are unaware of design features. In addition, there is a need for a maintenance cost estimate (e.g. \$300 per month per acre) and other guidelines (e.g. what specific tools to be used in specific systems). A construction design manual with a maintenance plan needs to be produced along with a modern database with information such as location, design, maintenance schedule, etc.

NPDES, phase II is coming on line in Minnesota in 2003. The Minnesota DOT is exploring ways to utilize water in existing permanent ponds for other things such as irrigation, or dispersal. The Minnesota DOT would like to have ponds drain down completely after storm events to simplify maintenance procedures that are otherwise very difficult to conduct in permanent or semi-permanent bodies of water. One option is to have ponds self-dewater using "top skimmers" such as the Faircloth Skimmer (<http://www.fairclothskimmer.com>). The Faircloth Skimmer is a device that improves sediment trapping efficiency by regulating the filling and draining of sediment basins better than the conventional methods that use perforated risers or stones. This

skimmer allows the adjustment of drain down and retention times. Also, the use of plants able to withstand periods of temporary flooding would further improve water quality. Draining ponds down following storm events would allow more room for incoming water from subsequent storm events. Currently, many ponds flush themselves clean: incoming water resuspends pollutants and washes them out of the overflow.

Metropolitan Mosquito Control District. Joe Sanzone, the director of Metropolitan Mosquito Control District (MMCD), was contacted by phone on December 18, 2000. During the AMCA meetings in Dallas, Texas, VBDS met with Nancy Read (technical services), also with MMCD. She works with mosquitoes in the urban environment. On March 16, 2001, Nancy e-mailed VBDS some additional comments to add to the questionnaire prepared by Joe Sanzone.

Summary of the phone conversation with Joe Sanzone. MMCD deals primarily with temporary rain pockets, especially along river, pond, and lake banks. There are extensive areas of swampy habitats created by rainfall in Minnesota. Over 90% of MMCD's mosquito work deals with *Ae. vexans* and *Coq. perturbans*, both major nuisance species during the summer months. However, in the southeastern region of MMCD's district, *Ae. triseriatus* mosquitoes that transmit LaCrosse encephalitis virus are also controlled. Joe Sanzone was not aware of BMP structures in his jurisdiction.

NEW JERSEY

Summary. VBDS investigated BMP / vector issues in New Jersey, with particular interest in Somerset County. Each of New Jersey's 21 counties has a vector control agency that is responsible for mosquito control (<http://www-rci.rutgers.edu/~insects/agencies.htm>). The Somerset County Public Works Department has groups involved with both mosquito control and BMP issues. The Road Division, Mosquito Extermination/ Drainage Section (<http://www-rci.rutgers.edu/~insects/somerset.htm>) includes personnel that conduct local vector control. The Engineering Division (<http://www.co.somerset.nj.us/division.htm>) is involved with BMP design, construction, and maintenance and has written a BMP manual for their county.

The New Jersey Department of Environmental Protection, Division of Watershed Management is a regulatory agency responsible for preparing the BMP manual for the state. It is available on the Internet (<http://www.state.nj.us/dep/watershedmgt/bmpmanual.htm>).

The New Jersey Department of Transportation (<http://www.state.nj.us/transportation/>) is responsible for construction and maintenance of BMPs associated with their roads throughout the state.

New Jersey Department of Environmental Protection. Liz Rosenblatt, the coordinator of the Nonpoint Source Pollution Program, in the Division of Watershed Management, was contacted by phone on April 24, 2001.

Summary of the phone conversation with Liz Rosenblatt. The New Jersey Department of Environmental Protection (NJDEP) is a regulatory agency that sets rules, reviews plans, and writes the BMP manual for the state. NJDEP has been very cautious regarding mosquito issues because of the current West Nile Virus situation in the state; however, they have not specifically amended BMP designs because of this. BMP structures are designed, built, and maintained by local governments, and any associated mosquito issues would be handled by local county health agencies.

Liz Rosenblatt told VBDS that Somerset County is home to a highly regarded stormwater engineers in the state, Joe Skupien, and suggested he be contacted. She also suggested contacting Vicki Thompson, formerly employed with NJDEP, and currently employed by the Monmouth County Mosquito Extermination Commission.

New Jersey Department of Transportation. Lad Szalaj, a civil engineer in Design Services, Civil Engineering (Hydrology and Hydraulics) section, was contacted by phone on April 24, 2001.

Summary of the phone conversation with Lad Szalaj. The New Jersey Department of Transportation (NJDOT) utilizes a number of different structural BMPs including water quality swales, extended detention basins (designed for a 72 hr drain down time), mitigation wetlands, and premanufactured underground units (e.g. Downstream Defender, Terra Clean, Vortechincs). The dense populations present in New Jersey require that many units be placed below ground. These underground systems require much more frequent maintenance and NJDOT does not have adequate staff to get to them all in a timely fashion. The reality is that many sites do not receive the maintenance they require. NJDOT will be evaluating the "loading rate" of many different premanufactured units to try and establish a better maintenance schedule for each type and for each location, otherwise, regular, required maintenance will not be done.

Lad Szalaj was not aware of mosquito issues associated with NJDOT structural BMPs. He suggested VBDS contact a great stormwater engineer in Somerset County who has been very proactive in stormwater management issues named Joe Skupien.

Somerset County Public Works Department. Joe Skupien, a civil engineer who works for the Engineering Division, was contacted by phone on April 30, 2001.

Summary of the phone conversation with Joe Skupien. Joe Skupien had an incredible wealth of knowledge regarding stormwater systems and has been involved with their design and implementation for many years. In addition, he also teaches stormwater management for engineers at Rutgers University, stressing real-world issues involved with BMP design and implementation.

Stormwater issues in New Jersey began in 1975 with peak discharge issues for flood and erosion control. All new development in the state has been subjected to water quality issues since 1975. Originally, peak flows from developed sites had to equal pre-development rates; however, it was soon discovered that in order to maintain a similar water level downstream, peak flows from developed sites had to be reduced to about 75% of the pre-development rate. To achieve flood and erosion control goals, dry detention basins and ponds were constructed. Ponds for this purpose were built 6-8 feet deep and had steep sides. Large regional watersheds were built in valleys that could be dammed to slow the flow from large drainage areas. Regional watersheds worked well, but New Jersey later passed a watershed protection law that prevented water storage in valleys and waterways. As a result, as of approximately 13 years ago, all stormwater management structures for quality and quantity have to be built at a local level (on site), on a comparatively small scale. There has been a considerable amount of research done comparing the benefits of regional facilities (i.e. large watersheds) used to treat stormwater runoff from large areas versus the construction of multiple smaller units designed to treat runoff from small areas.

There are hundreds of stormwater management structures in Somerset County, most which grew out of flood control (i.e. dry detention). Somerset County Public Works has been gradually weaning off structural BMPs to private owners and associations for maintenance. Currently, about 25% are contracted with private contractors for maintenance, whereas the remaining 75% are maintained by Public Works. The philosophy of Somerset County engineers has been to build "very dry" detention systems, or "very wet" ponds to prevent public health threats. In general, infiltration devices are not effective in New Jersey due to poor soil permeability.

Shallow wetland BMPs are best for water quality. The environmental groups, such as the New Jersey Department of Environmental Protection, have been pushing to have more shallow systems built. They believe that the comparatively lesser performance of extended detention basins for water quality warrants the construction of wetlands. In contrast, Somerset County has been pushing for dry systems which are cheaper to build, require far less maintenance, do not require specially trained professionals to work on them, and are more acceptable to homeowners. County

engineers have built concrete low-flow exit channels into extended detention basin (EDB) designs to improve the function of the EDB and simplify maintenance. Maintenance is essentially reduced to scraping and removing sediments accumulated on the concrete, and removing trash from the outlet screen and the basin floor. This has been a controversial issue with the environmental groups because they feel that the percent pollutant removal is reduced. Joe Skupien argues that EDBs built with these features function just as well as others, with the added benefit that the ease of maintenance (that anyone can do) will allow these units to function better in the long run. Joe Skupien believes that wetlands do work well for water quality, but require far too much management and maintenance of living organisms and pollutant uptake processes of the constructed habitat. There are far too many structural BMPs that require more time and expertise than most people are willing to put into them.

New Jersey has severe mosquito problems and the hysteria created by West Nile Virus by the media has made vector control a hot topic. Shallow wetland BMPs seem to be best for water quality, but are tremendous mosquito producers. These areas require that trained applicators with expertise in mosquito control be called upon for abatement. Joe Skupien feels that mosquito problems in dry detention systems can be solved much more quickly and easily by removing clogs in the system and allowing them to drain properly. It is his opinion that very few stormwater engineers and designers think about the details that are needed in field applications compared to the theoretical they create on paper. They need to create a better balance of theoretical versus actual. It is especially important that those involved in the design and construction of wetlands have expertise in this subject and commitment to the project. In addition, water quality has to be balanced with public health issues.

Somerset County Public Works engineers are actively involved with County vector personnel in the Mosquito Extermination/ Drainage Section, within the Road Division. The vector group has two foremen that are split up by expertise. Joe Skupien works closely with Jack Pinone, one of the foremen, on BMP design recommendations. Joe Skupien recently consulted with Jack Pinone regarding plans for a new 11-acre wetland project. Both men then present their ideas to the consultants involved with the design and construction. An example of a subject they frequently discuss with contract

engineers is access to sites. Both maintenance crews and vector control personnel have to have access to structures. The better the access is made, the less time is required to conduct routine inspections and maintenance. A simple access road that allows an inspector to drive up to a structure and be able to look at it from the car can reduce time spent at a site by over 2/3rds. The Engineering Division was responsible for preparing a BMP manual for the County. After consulting with a variety of different groups, the biggest concern was site accessibility.

OREGON

Summary. VBDS investigated BMP / vector issues in Oregon, with particular interest in and around the City of Portland (i.e. Washington and Multnomah Counties). Washington County does not have a vector control program. Additional information on this county can be found on the Internet (<http://www.co.washington.or.us/cgi/home/washco.pl>). Mosquito control in the city of Portland and throughout Multnomah County is conducted by Multnomah County Health Department, Vector Control (www.multnomah.lib.or.us/health/contprev/pests/). This agency concentrates most of its control efforts along the Columbia River in, but also does contract work in a very small area of Washington County.

The state of Oregon manages water quality with two different NPDES permits. The City of Portland manages a municipal NPDES permit with co-permittees Port of Portland and Multnomah County. The City of Portland has several bureaus, and 4 city commissioners. The most important bureau with regards to water quality is the Bureau of Environmental Services (<http://www.enviro.ci.portland.or.us/>). The BMP manual for the City of Portland provides information on all aspects of the city's stormwater program and is available on the Internet (<http://www.enviro.ci.portland.or.us/swp.htm>). It appears that several other state and local agencies may be involved with stormwater runoff and the NPDES permits such as the Portland Department of Transportation (<http://www.trans.ci.portland.or.us/TransServices.asp>). The Port of Portland (<http://www.portofportland.com>) is responsible for operating airports, marine terminals, and the import/export of cargo through the Columbia River. They are involved with many aspects of water quality including wetland mitigation and restoration within their jurisdiction.

The Oregon Department of Transportation (ODOT) (<http://www.odot.state.or.us/>) used to be a co-permittee on the municipal NPDES permit with the City of Portland. As a result of an agreement with the Department of Environmental Quality, ODOT now operates its stormwater program under its own state NPDES permit. Their BMP handbook entitled "Road Maintenance Water Quality & Habitat Guide" is available on the Internet (www.odot.state.or.us) under the subheading "Environment".

Multnomah County Health Department, Vector Control. David Turner, the mosquito control field supervisor, was contacted by phone on Jan 29, 2001, and several times thereafter. David Turner and the vector control program supervisor, Chris Wirth, agreed to host an organized tour of Portland BMPs for VBDS, Larry Walker Associates, and Caltrans on March 6th and 7th, 2001 that would include representatives from the City of Portland, Bureau of Environmental Services, and the Oregon Department of Transportation (see Appendix B).

Summary of several phone conversations with David Turner. There is no state vector control program in Oregon. Multnomah County Health Department, Vector Control (MCVC) is responsible for surveillance and abatement of vectors throughout Multnomah County and occasionally does contract work in a small part of Washington County.

Portland has a multitude of stormwater management and pollution control devices associated with freeways, roadways, parking lots, industrial parks, and housing developments. The city also has hundreds of underground catch basins and sumps that hold water for long periods of time, if not indefinitely. Stormwater management devices that catch debris are mandatory even at private residences when artificial surfaces (roofs, driveways, etc) exceed 500 sq. ft. These devices create suitable habitats for mosquito reproduction in addition to the extensive natural breeding sites in the area. MCVC is severely understaffed to do the widespread control of mosquitoes in natural and created habitats needed in Multnomah County.

MCVC works closely with several different agencies that manage various bodies of water including the Port of Portland, the City of Portland, Bureau of Environmental Services (BES), and the Department of Transportation. The relationship between MCVC and BES is not ideal. They have conflicts over jurisdiction and vector issues. Apparently, BES funds most of the city's rodent sewer baiting program, but some is contracted due to its extensiveness. On other issues, BES is apparently reluctant to acknowledge that some of their facilities and structures are significant sources of vectors. Because of this, they do not want to support vector surveillance and abatement at these sites. In contrast, MCVC has a good working relationship with the

Port of Portland which has gone above and beyond the needed financial support for vector control in their mitigation wetlands sites.

Dave Turner suggested that VBDS contact for Scott Carter, a wetland restoration specialist, at the Port of Portland for additional information on BMP structures.

Port of Portland. Scott Carter, a wetland restoration specialist in the Properties and Development Section, and Dorothy Sperry (involved with NPDES permits), were contacted by phone on Feb 16, 2001. Dorothy provided VBDS with a few pages of information on BMP types later the same day.

Summary of the phone conversation with Scott Carter. The Port of Portland is responsible for operating airports, marine terminals, and the import/export of cargo through the Columbia River. They are involved with many aspects of water quality including wetland mitigation and restoration within their jurisdiction. Scott Carter has a background in landscape, but is currently involved with wetland creation, mitigation, and restoration. He mentioned that Portland has a lot of floodwater situations, clay soils that promote surface water build-up, and wetlands. One of the projects he has been involved in is on Government Island (2500-2700 acres), in the Columbia River. This island was historically used for grazing cattle, but recently became the site for an approximately 400 acre wetland mitigation (mostly emergent wetland) constructed by the Port of Portland. This mitigation wetland created huge numbers of floodwater mosquitoes. To avoid possible complaints from citizens living along the river, the Port of Portland provides Multnomah County Health Department, Vector Control with funding to abate mosquitoes in approximately 350 acres of the mitigation site. Scott Carter is also currently involved with a wetland mitigation site adjacent to the Portland Exposition Center.

Scott Carter suggested that VBDS contact Dorothy Sperry, who works on NPDES permit issues in the same department, and Dave Hendrix, who deals with NPDES permit issues for the Multnomah County Drainage District (MCDD). MCDD is responsible for managing slews and drainage ways of the Columbia River, as well as operation of the dike that separates the river from the airport and the north part of the city, used for river overflow.

Summary of the phone conversation with Dorothy Sperry. Dorothy Sperry spent some time trying to explain the complexities of the NPDES permit within the different agencies. The Port of Portland, City of Portland, and Multnomah County are all co-permittees for the municipal NPDES permit. Apparently the Oregon Department of Transportation used to be a co-permittee, but as a result of an agreement with the Department of Environmental Quality, now operates its stormwater program under its own state NPDES permit. One of the problems Dorothy Sperry has encountered with regard to BMPs is that they are difficult to evaluate or quantify for effectiveness because there is no established way of doing it. She mentioned that each site creates its own unique situation making comparisons biased or impossible. She was very interested in knowing more about stormwater issues in California.

Dorothy Sperry suggested that VBDS contact Patrice Mango, the stormwater program manager for the City of Portland, Bureau of Environmental Services, responsible for coordinating all the bureaus for stormwater related issues, and Jeff Moore, the assistant environmental program coordinator for the Oregon Department of Transportation, who deals with stormwater issues.

City of Portland, Bureau of Environmental Services. Katie Bretsch, the program manager for the Bureau of Environmental Services (BES), was contacted by phone on February 23, 2001. Patrice Mango, with the BES planning group, was contacted by phone on February 26, 2001, who then forwarded the VBDS survey to her colleague, Dawn Hottenroth, an environmental specialist with the BES Stormwater Program. Dawn Hottenroth, contacted VBDS by phone on March 5, 2001.

Summary of the phone conversation with Katie Bretsch. The City of Portland is made up of 4 bureaus, each responsible for different aspects of the city. BES is in charge of the NPDES permit for the City and includes the Port of Portland and Multnomah County as co-permittees. Katie Bretsch is primarily responsible for stormwater BMP designs, their maintenance, and current operations, specifically those that are built by BES for stormwater management or for any stormwater runoff from the public right-of-way (i.e. culverts, roadside drains). She views the spraying of Bti (a microbial larvicide) as having been successful for control of mosquitoes in open water

areas. The cost involved is not excessive as viewed by BES standards, and the cost-per-acre is not unreasonable. If it is a question of spraying versus redesign of a stormwater structure such as an open pond, BES will opt to spray. Multnomah County Vector Control has asked BES to redesign ponds (i.e. don't vegetate perimeters of ponds and water margins); however, BES is unwilling to modify them because it would reduce the ability of ponds to remove pollutants.

Katie Bretch suggested that VBDS contact her counterpart at the Oregon Department of Transportation, Jeff Moore, and her counterpart at the Multnomah County DOT, Don Newell, the road maintenance system administrator.

Summary of the phone conversation with Patrice Mango. Patrice Mango is with the BES planning group that looks at BMPs in more of a long-range. She manages the NPDES stormwater permit citywide and is responsible for writing up the annual report for the municipal NPDES permit that includes BES, the Port of Portland, and Multnomah County. BES is using the Endangered Species Act (ESA) as leverage to push their water programs forward, especially as they relate to endangered salmon species that utilize local waterways for spawning.

Patrice Mango provided VBDS with a lot of interesting information on future goals for water quality in and around Portland and information on new BMPs. BES is working on the development of a "Green Streets Program" to create stormwater-management-friendly streets in residential areas. Another BMP under examination is the "Eco Roof", that would reduce the volume of stormwater runoff (acting similar to an extended detention basin) and improve water quality. This BMP is designed for use on the tops of buildings. A special impervious roof lining is covered with soil of about 4 inches deep, specific soil mixes, and specific plant communities (based on the climate). Due to the mass created by the Eco Roof, the building, and particularly the roof, has to be designed to support more weight. The Eco Roof filters bacteria and pollutants, acts as a building insulator against heat and cold, and reduces urban "heat island effect", improving air quality. Apparently the GAP headquarters in San Jose has a functional Eco Roof.

Patrice Mango suggested VBDS contact Liane Welch, an engineer who works on maintenance protocols for city facilities with the City of Portland, Bureau of Maintenance, who might have more information on BMP maintenance activities. Patrice Mango also mentioned that she would speak with Dawn Hottenroth, a lead person on OMM issues of BMPs in BES, who knew more about vector issues.

Summary of the phone conversation with Dawn Hottenroth. Dawn Hottenroth is an environmental specialist with the BES Stormwater Program. She works on policy and design issues associated with stormwater. She wrote a part of the early BMP manual for the City of Portland, BES. Dawn Hottenroth has knowledge on vector issues because she worked with San Diego County Environmental Health, Vector Control in the early 1990's. She agreed to complete a questionnaire for VBDS with any information she could provide.

Oregon Department of Transportation. Jeff Moore, the environmental program coordinator for the Oregon Department of Transportation (ODOT), Clean Water Unit, was contacted by phone on February 26, 2001.

Summary of the phone conversation with Jeff Moore. Jeff Moore is directly involved with the NPDES permit for ODOT. ODOT has made big improvements in the past 5 years in understanding how various BMPs for stormwater will perform. They have been gradually moving away from the use of wet ponds for water quality because of maintenance issues. It is difficult to remove all of the contaminated sediment from wet ponds and the work (i.e. draining, dredging, etc.) is very labor intensive. The last wet pond clean out was 3-4 years ago due primarily to a bacterial bloom in the water, not necessarily because the pond was ready for total sediment clean out. ODOT is in favor of other BMP structures that are easier to maintain such as swales.

Many areas of Portland have fine clay soils that, once suspended in water, take weeks or months to settle out. This reduces the water quality benefits of many BMPs for stormwater. Recently, many of ODOT's new BMPs do not involve structures, but rather are changes in procedures and protocols that reduce the quantity of pollutants in water runoff.

Jeff Moore suggested that VBDS contact Paul Wirfs, an urban hydraulic engineer within the ODOT Geology Unit, who is a designer and works with water quality issues statewide, and Paul Wirfs' counterpart, Randy Inloes, the maintenance supervisor in the Portland district that contains the most ODOT water-quality ponds who would better know the day-to-day practicalities of these BMPs.

TEXAS

Summary. VBDS investigated BMP / vector issues in Texas, with particular interest in the City of Austin. Mosquito collection and control in and around Austin is conducted by the Austin / Travis County Health and Human Services Department, Environmental Health Services, Rodent and Vector Control (<http://www.ci.austin.tx.us/health>). The Texas Department of Health, Zoonosis Control Division (<http://www.tdh.state.tx.us/zoonosis>) will identify mosquito samples submitted by the Austin / Travis County Health and Human Services Department, but is not involved directly with day-to-day field activities.

The City of Austin, Watershed Protection & Development Review Department is involved with many aspects of BMPs for stormwater runoff. Many of their ongoing activities with water quality BMP structures, including the Central Park Wet Pond, discussed in the Austin visit report (see Appendix C), can be viewed on the Internet (<http://www.ci.austin.tx.us/watershed>).

The Texas Department of Transportation (<http://www.dot.state.tx.us>) has built 6 BMP structures in Austin and is expecting to be mandated to build many more throughout the state in the near future as state regulations change.

Glenrose Engineering is a consulting firm based in Austin that is involved with stormwater issues. They are currently working with Caltrans in California as a third party in the Caltrans "cost group" that is trying to make BMPs affordable while functional. This company was selected by the Natural Resources Defense Council to help produce a productive and cooperative cost report.

Texas Department of Health, Zoonosis Control Division. Julia Rawlings, in the Zoonosis Control Division, was contacted by phone on March 26, 2001. Robin Seiferth, an entomologist in the parasitology / entomology branch, was contacted by phone on April 9, 2001.

Summary of the brief phone conversation with Julia Rawlings. Julia Rawlings is a specialist in zoonotic diseases and was not aware of issues related to mosquito production in stormwater management structures. She did not appear to have any

knowledge of stormwater BMPs. The Texas Department of Health, Zoonosis Control Division does not monitor or control mosquitoes in and around Austin. Austin / Travis County HHSD collects samples and performs abatement. The State will do the species identifications. Julia Rawlings suggested that VBDS contact Paul Fournier, the supervisor of the parasitology / entomology branch, for additional information.

Summary of the brief phone conversation with Robin Seiferth. Robin Seiferth had never heard of stormwater BMPs, thus was unable to provide VBDS with information on vector production associated with these structures. She suggested VBDS contact the Austin / Travis County Health & Human Services Department for information on mosquito issues in urban structures.

Austin / Travis County Health and Human Services Department. At the AMCA meeting in Dallas in February 2001, I found out that. I contacted Barrie Turano, the supervisor for Environmental Health Services, Rodent and Vector Control program, by phone on March 19, 2001.

Summary of the brief phone conversation with Barrie Turano. The Austin Rodent and Vector Control program seeks to control disease-carrying insects and rodents by providing baiting services, door-to-door educational outreach, coordination of neighborhood cleanups with the City of Austin Solid Waste Services Department, eliminating mosquito larva in standing water, and, when appropriate, spraying for mosquitoes in residential areas outside the city limits. Mosquito spraying within the city limits is performed in developed, recreational areas within the city-operated park system. The Austin Rodent and Vector Control program has no involvement with BMPs in Austin. In the event of a complaint, they will make a site assessment and, if appropriate, will abate vectors.

Barrie Turano suggested that VBDS contact Tom Bshara at the Austin Watershed Protection Agency for additional information.

City of Austin Watershed Protection & Development Review Department. Mike Kelly, an engineer in the Environmental Resource Management Division, was

contacted by phone on February 20, 2001. Pat Hartigan, the project coordinator for the department, was contacted by phone on April 10, 2001.

Summary of the brief phone conversation with Mike Kelly. The City of Austin Watershed Protection & Development Review Department stocks all of their constructed wet ponds with mosquitofish, *Gambusia affinis*, for mosquito control. However, ponds retrofitted into existing neighborhoods are often met with resistance from local residents who fear mosquito problems. Austin Watershed Protection apparently has no working relationship with the Austin / Travis County Health and Human Services Department, Environmental Health Services, Rodent and Vector Control.

Mike Kelly suggested that VBDS contact others within Austin Watershed Protection including Les Tull, who is in charge of BMP design, and either Pat Hartigan or John Gleeson, who should have more knowledge on mosquitoes. Mike Kelly suggested that VBDS contact Matt Hollon, with Glenrose Engineering in Austin.

Summary of the phone conversation with Pat Hartigan. There are hundreds of Austin-type sand media filters in and around Austin. Sand filters are associated with all new development. Their purpose is two-fold: to reduce pollution in runoff entering natural watersheds, and to improve hydrology by reducing the volume of water (by slowing it) that enters the watersheds. The increased volume of water runoff created by urban expansion was resulting in rapid erosion (and additional sediment loads) of stream embankments. These structures are generally trouble-free unless they receive large sediment loads. With large sediment loads, sand filters are prone to clogging.

Pat Hartigan mentioned that design and maintenance issues are addressed in Austin BMPs; however, maintenance is not regularly performed. Maintenance of sand filters is done by "crisis management", where the Austin Watershed Protection will respond to complaints of clogged filters or filters will be cleaned if City employees happen upon clogged units. In areas with slow-draining soils, water may stand for various lengths of time.

Pat Hartigan was not aware of mosquito problems associated directly with BMPs in Austin. He mentioned that all ponds are stocked with mosquito fish for mosquito control. Some of the flood-control ponds were designed to drain completely in a short

period of time; however, many frequently contain permanent bodies of water. He stated that it was his opinion that the numerous creeks in and around the city as well as urban and residential water standing in private residences probably contributed more to mosquito reproduction than structural BMPs.

Pat Hartigan suggested that VBDS contact Tom Schueler, the founder of the Center for Watershed Protection (CWP) (www.cwp.org). He mentioned that CWP had put out numerous publications on stormwater issues and may have information on vectors associated with BMP's.

Glenrose Engineering. Matt Hollon, a stormwater engineer, was contacted by phone on February 20, 2001. He was instrumental in organizing a half-day tour of representative structural BMPs in Austin on February 21, 2001 (see Appendix C) on very short notice with himself and Mike Barrett (University of Texas) for VBDS.

Summary of the brief phone conversation with Matt Hollon. Glenrose Engineering works with Caltrans as a third party in the Caltrans "cost group" in trying to make BMPs affordable while functional. This company was selected by the Natural Resources Defense Council to help produce a productive and cooperative cost report. Matt Hollon mentioned that Austin has several criteria associated with the construction of water quality BMPs, for example, non-permanent pools must drain in 72 hours or less and wet ponds are always stocked with mosquito fish. He also mentioned that he was not aware of any regular maintenance done to these structures. However, it is his opinion that water quality ponds probably do not contribute much to the background numbers of mosquitoes present in the city because of the thousands of natural and residential breeding sources.

Texas Department of Transportation. Jay McCurley, in the Advanced Planning Division, was contacted by phone on April 9, 2001.

Summary of the phone conversation with Jay McCurley. Jay McCurley is an "environmentalist" who works for the Texas Department of Transportation (TDOT) office in Dallas. He was knowledgeable on both vector issues and BMP issues. He had previously worked in vector control with the Dallas HHS Environmental Branch before

accepting a position with TDOT. He was not aware of anyone in TDOT who had been considering vector issues with regard to stormwater runoff, BMPs, or both. Part of the reason for this is because TDOT has very few structural BMPs. They built 6 sand filters in the city of Austin as a result of a previous litigation, but have not built any before or since. Jay McCurley was not aware of the maintenance schedule that TDOT had planned for the sand filters in Austin.

Sand filters were originally designed to drain in 24-48 hours, with no consideration of the sand media that quickly clogs. TDOT did not and does not want to have to build sand filters because of the frequent maintenance they require due to clogging. Where possible, TDOT will utilize vegetative cover techniques (including grassy swales and grass-lined ditches) because they provide similar pollutant removal from water runoff compared to more complex structures, they require almost no maintenance, and they are very cheap to build. Jay McCurley mentioned that as a result of ever-stringent regulations, TDOT would be required to build specific types of BMPs in the very near future including infiltration basins, wetlands, detention and retention ponds, and others. Many of these will probably need to be retrofitted into existing constructed areas.

VIRGINIA

Summary. VBDS investigated BMP / vector issues in Virginia, with particular interest in the northern region of the state adjacent to the District of Columbia. The Virginia Department of Health, Office of Epidemiology (<http://www.vdh.state.va.us/epi/newhome.htm>) makes recommendations on vector control and surveillance statewide, but is not involved with monitoring, surveillance, or abatement. The Virginia Department of Health also has a Division of Water Supply Engineering (<http://www.vdh.state.va.us/dwse/index.htm>) that is involved with human health issues related with water, but not directly with structural BMPs.

Mosquito control agencies in the state of Virginia are concentrated primarily along the southern coastal areas of the state, around the cities of Suffolk, Chesapeake, Norfolk, Hampton, and Yorktown. In the northern region of the state, Prince William County Public Works (<http://www.co.prince-william.va.us/pworks>) has a Gypsy Moth and Mosquito Control Branch that is responsible for vector surveillance and control. The Fairfax County Health Department (<http://www.co.fairfax.va.us/service/hd/hdweb.htm>) and the City of Alexandria Health Department (<http://ci.alexandria.va.us/city/health>) both historically had active mosquito control program until local government downsizing cut the programs. In part due to the appearance of West Nile Virus in the area, both department are trying to obtain funds to re-establish vector control programs. Information on all local health districts in Virginia can be found on the Internet (<http://www.vdh.state.va.us/lhd/02.htm>).

The Virginia Department of Environmental Quality (<http://www.deq.state.va.us/>) is in charge of NPDES permits, but is not directly involved with BMPs. The Virginia Department of Conservation and Recreation, Soil and Water Conservation Program (DCR) (<http://www.dcr.state.va.us/sw/index.htm>) is the agency that is in charge of BMP design and implementation issues for non-point source pollution. In the northern region of the state, several selected agencies that are responsible for stormwater related issues and structural BMPs were contacted including Prince William County Public Works (<http://www.co.prince-william.va.us/pworks>), Fairfax County Public Works and Environmental Services Department

(<http://www.co.fairfax.va.us/gov/dpwes/homepage.htm>), and the City of Alexandria Department of Transportation and Environmental Services (http://ci.alexandria.va.us/city/tr_es_ut_idx.html).

The Virginia Department of Transportation (<http://www.vdot.state.va.us/>) has worked with DCR to develop a statewide program addressing non-point pollution from stormwater runoff. They have a group called the Virginia Transportation Research Council (VTRC) (<http://www.vdot.state.va.us/vtrc>) that works in conjunction with the University of Virginia on BMP research activities. VTRC recently completed a study called *Testing of Ultra-Urban Best Management Practices*, written by Yu, S.L., and Stopinski, M.D. The article is available on the Internet at VTRC's website (http://www.vdot.state.va.us/vtrc/main/index_main.htm).

Virginia Department of Health, Division of Water Supply Engineering. Allan Weber, an engineer, was contacted by phone on April 13, 2001

Summary of the phone conversation with Allan Weber. The Division of Water Supply Engineering provides the State Department of Health with information on environmental assessments, but is not involved with BMP design, implementation, or maintenance. Allan Weber mentioned that in his experience, the primary BMP types built in Virginia are mitigation wetlands and sedimentation ponds. He suggested that VBDS contact the Department of Conservation and Recreation as well as the Department of Environmental Quality for information on vectors and BMP structures.

Virginia Department of Health, Office of Epidemiology. David Gaines, the entomologist for the State Department of Health, was contacted by phone on April 16, 2001.

Summary of the phone conversation with David Gaines. One of the tasks of the Office of Epidemiology is to make recommendations on mosquito control and surveillance, but this Office is not involved with monitoring, surveillance, or abatement. David Gaines mentioned that mosquito control in the state of Virginia as a whole is relatively low, especially in the northern section, thus there is not much data on mosquito production. Almost all the mosquito control programs in the state are

concentrated along the southern coastal regions, especially in tidal salt marsh areas, where the population of people is most dense. Mosquito control is locally funded, therefore areas with large populations generally have a larger tax base that can support a mosquito control program, whereas less densely populated regions may not have the tax base to support a program. In the northern region of the state, there is a mosquito control program in Prince William County, (a wealthy county) that does mosquito control along the Potomac River as well as in urban areas. There has been at least one case of Malaria which appeared to have been contracted locally in the northern "neck area" of the state in a rural / agricultural area. *Anopheles* mosquitoes that can transmit malaria are very common in Virginia.

David Gaines was familiar with underground catch basins as well as above ground retention basins in Virginia. Water retention basins are designed with overflows, for when the water load is too high, but otherwise only drain by infiltration and/or evaporation. Many of these structures do not drain because of thick clay soils in many areas of the state and as a result can become sources of mosquitoes. From David Gaines' recollection, most of the BMP structures he has seen were associated with parking lots and new housing developments. He mentioned that many are surrounded by chain link fences and are not aesthetically pleasing. Apparently, roadside ditches frequently hold water for long periods of time and may become sources of mosquitoes.

David Gaines suggested that VBDS contact Dreda McCreary, the manager of Virginia Beach Mosquito Control, because she should have good knowledge on mosquito control in the state, and Kim Largen, at Prince William County Mosquito Control, for information on mosquitoes in northern Virginia.

Virginia Department of Environmental Quality. Burton Tuxford, of the Water Division, was contacted by phone on April 13, 2001.

Summary of the phone conversation with Burton Tuxford. The Virginia Department of Water Quality (VDEQ) is primarily responsible for enforcing state requirements and reviewing NPDES permits. VDEQ issues NPDES permits for the state of Virginia and specializes in point-source pollution issues, not non-point source issues, and are not involved in any aspect of BMP design or implementation.

Burton Tuxford suggested that VBDS contact the Department of Conservation and Recreation, Soil and Water Conservation Program, which is responsible for prescribing BMP methods and writing the state manuals for non-point source pollution. Specifically, he suggested speaking with Jack Frye, the head of the division, and Joe Battiata, one of the people involved directly with stormwater issues. Burton Tuxford also suggested VBDS contact Rick Woody, with the Virginia Department of Transportation, who is involved with BMPs in their stormwater program.

Virginia Department of Conservation & Recreation. Joe Battiata, the Stormwater Program Manager for the Soil and Water Conservation Program, was contacted by phone on April 17, 2001.

Summary of the phone conversation with Joe Battiata. Joe Battiata provided a considerable amount of information regarding structural BMPs. Erosion and sediment control in Virginia has been mandatory for approximately 20 years. The Virginia Department of Conservation and Recreation (VDCR) was historically involved with agricultural non-point source pollution. In 1990, after the passing of new stormwater programs and the arrival of NPDES permit requirements, VDCR adopted all aspects of non-point source pollution and became responsible for writing the BMP manual for the state. VDCR is the central stormwater BMP coordinator for all related research and/or studies in the state. VDCR works through local governments for BMP implementation. The chain is as follows: local government pays the Virginia Department of Environmental Quality for an NPDES permits, then they work with VDCR for oversight of local programs.

Interestingly, stormwater programs are not mandatory for local governments. In early 1990, 11 local governments adopted the stormwater program, with an additional 7 since then. With the recent advent of NPDES Phase II, another 43 local governments are expected to adopt the stormwater program over the next few years. There are a total of 166 local governments throughout the state that could eventually be involved with the stormwater program.

There are many different structural BMP designs in Virginia. Ponds and extended detention basins (EDB) have been used extensively. Many structures were

built in commercial areas behind buildings and fell into serious disrepair, possibly due to “the out of site, out of mind” theory. New structures are usually built out front, in view of people, and provide aesthetic value through careful landscaping and design. These new structures tend to be better maintained since they are highly visible. A new "enhanced" EDB design is being evaluated. These structures incorporate a marsh on the basin floor, which serves to prevent re-suspension of pollutants when new water enters the structure. Many of these enhanced EDBs have permanent to semi-permanent water.

There are a number of underground BMP structures, most of which are manufactured proprietary units such as Stormceptors, CDS, Vortech, etc. As a general rule, these filtering devices are good for removing total suspended solids (TSS), but are ineffective at removing nutrients such as nitrogen and phosphorous. Also, as flow rate increases through these units, efficiency decreases due to flow bypass. Vortech units have a much greater volume capacity than most others and thus are generally more effective simply because there is less chance of flow bypass. Maintenance of these units is required by the property owners. Property owners usually opt to sign an annual contract with a contractor (usually a representative of the BMP manufacturing company) for inspections and maintenance. As a result of required maintenance and/or contract agreements, these manufactured underground units are generally kept neat and reliable.

Some BMP structures have been built "offline" from main storm sewers. Low-flow diversions from the main storm sewer line feed these units. This allows smaller treatment structures to be built. The state also has several different types of sand filters including Delaware and Austin types.

As far as comparing efficacy of different structures, Joe Battista mentioned that data is very scattered (e.g. 10 - 90% removal efficiency). This includes comparisons of similar designs as well as new versus older designs. In many cases, pollutants can become re-suspended when new water enters a BMP, affecting removal efficiency evaluations over time. This is what led to the "enhanced" EDBs, where the shallow marsh prevent some resuspension from happening.

Maintenance is a key factor in the function of all BMP structures in Virginia. Lack of maintenance usually results in gradual breakdown of the system and even failure of the structures. Over the past 10 years, monitoring efforts have shown that "percent removal efficiency", the criteria that has been used up to now to evaluate BMP performance, is somewhat meaningless. For example, two BMP units are compared for efficiency based on percent removal efficiency: one receives water with a high concentration of TSS and 90% of the TSS are removed by the BMP, the other receives relatively clean water with only background levels of TSS and nutrients and only 5% of the TSS is removed. Do these results indicate that the unit receiving the cleaner water is a poorer performer? VDCR is beginning to look more closely at downstream fauna to better determine the efficacy of stormwater BMPs rather than at percent removal efficiency.

Regarding mosquitoes, Joe Battiatà mentioned that VDCR suggests that permanent water structures include "depth zones" to promote an ecosystem balance. This should provide suitable habitat for natural predators of mosquitoes. However, small pockets of water become a source of vectors, and some BMP designs hold stagnant water. In general, BMPs that were designed correctly experienced few mosquito problems.

Virginia Department of Transportation. Rick Woody, the program manager for the Aquatic Ecology Program, in the Environmental Division, was contacted by phone on April 16, 2001.

Summary of the phone conversation with Rick Woody. The Virginia Department of Transportation has a water quality research group that works in conjunction with the University of Virginia. This group is called the Virginia Transportation Research Council (VTRC) and they do research on the performance of stormwater BMPs. VTRC recently completed a study called *Testing of Ultra-Urban Best Management Practices*. Rick Woody suggested that VBDS contact Mike Fitch at VTRC for more information on BMP structures.

Virginia Transportation Research Council. Mike Fitch, a senior research scientist, was contacted by phone on April 23, 2001.

Summary of the phone conversation with Mike Fitch. The Virginia Transportation Research Council (VTRC) was formed out of a cooperative agreement between the Virginia Department of Transportation (VDOT) and the University of Virginia, in Charlottesville. VTRC is the research branch of VDOT that works out of the University of Virginia, Civil Engineering Department. VTRC receives federal and state funding for research on all things related to transportation such as safety, materials testing, intelligence transportation systems (ITS), and environmental issues. An advantage of being associated with the University is access to graduate students for conducting research. The total VTRC staff is approximately 200, 50 of which are full-time. Mike Fitch's environmental research group has 4-5 full-time staff.

Mike Fitch's environmental research group has a major focus on stormwater BMPs. In recent years, VDOT has been under pressure to implement "Ultra-Urban BMPs" (a term used to describe manufactured units such as CDS, Stormceptor, Vortech, etc.), in part as a result of corporate marketing that emphasizes the high removal rates possible with these structures. A graduate student with VTRC recently finished a research project focused on Ultra-Urban BMP structures as well as other BMPs such as grass swales and different types of vegetation and landscaping used along highways and parking lots.

Maintenance issues associated with structural BMPs are a major concern to VDOT. If structures are infrequently maintained, or if a large storm event occurs, pollutants are often resuspended and washed out of BMP structures, completely nullifying their intended purpose. In contrast, if structures are regularly maintained and cleaned out, pollutant removal rates remain relatively high. Unfortunately, overall performance of structural BMP technology types is difficult to quantify because efficacy data varies widely from structure to structure.

The cost associated with BMP maintenance and the personnel needed to effectively run a program has been difficult to "sell" to VDOT. It has been difficult to come up with a maintenance plan that can be effectively implemented. In addition, the issue of what to do with materials removed from BMP structures during clean-outs still

remains. Does this material become classified as toxic waste, hazardous waste, or otherwise, and how should it be disposed.

VDOT is concerned with vector issues within their BMP structures, especially with the spread of West Nile Virus (WNV) into Virginia. In 2000, there were approximately 7 birds diagnosed as seropositive to WNV in Virginia and this was a major concern for VDOT. VDOT would prefer to handle the vector issues within their BMP structures proactively through careful planning and prevention; a task currently being studied by VTRC.

Prince William County Public Works. Two people in the Environmental Services Division were contacted. Lou Jones, in the Gypsy Moth and Mosquito Control Branch, was contacted by phone on April 16, 2001. Oscar Guzman, in the Watershed Management Branch, was contacted by phone on April 17, 2001.

Summary of the phone conversation with Lou Jones. The mosquito control program in Prince William County is small, with 4 full time field staff. Vectors are controlled using both adulticide and larvicide techniques. In contrast to other areas in the northern part of Virginia, vector control treatments in Prince William County frequently involve adulticiding. Apparently, there is some pressure from "old timers" who have the "spray philosophy", regardless of the outcome.

There is a lot of growth in Prince William County and it may soon become a suburb of Washington DC. Lou Jones mentioned that most new housing tracts had detention/retention ponds associated with them. These frequently become sources of mosquitoes when they are not maintained. Overwintering adult *Cx. pipiens* mosquitoes have been collected in manholes.

Lou Jones suggested that VBDS contact Bruce Harrison, at the North Carolina Department of Health, and John Neely, in Craven County, North Carolina, for more information on vector related issues.

Summary of the phone conversation with Oscar Guzman. The concept of BMPs originated in northern Virginia in the mid 1970's, originally to protect the drinking water source in that area. In 1990, the Chesapeake Bay Act was passed which greatly

expanded the scope of clean water in the state of Virginia. There are hundreds of structural BMPs in Prince William County. There are several different types including extended detention basins (EDB), bioretention marsh areas, Stormceptors, and permanent ponds. EDBs are designed to drain dry in 40 hours or less, but due to clogging and lack of maintenance, mosquitoes often utilize them for breeding. As a result, the County has received public complaints of mosquitoes in ponds and EDBs. When this happens, County maintenance crews visit the sites to do maintenance and repairs if necessary. Several EDBs have been retrofitted with baffles to improve draw down time while preventing clogging and ultimately reducing the required maintenance.

Bioretention marshes are generally used in small drainage areas of 1 acre or less and filter water through a vegetated marsh zone. Water then infiltrates (preferred method), or is allowed to run off (where clay soils prevent infiltration). Stormceptors are generally only used for pre-treatment purposes, not water quality, because they do not remove enough pollutants. The County has few permanent ponds.

Fairfax County Health Department. Roy Eidem, the environmental health supervisor, was contacted by phone on April 17, 2001.

Summary of the phone conversation with Roy Eidem. Fairfax County does not have an active mosquito control program. Apparently the county did have a program until the local government was downsized in 1992, eliminating mosquito control. The current situation with West Nile Virus (WNV), and the recent find of a WNV positive bird in Fairfax County last year, has driven Fairfax County Health Department to try to obtain funds to re-establish a mosquito control program.

Roy Eidem is currently responsible for advising and education on mosquito-related issues. There is a County ordinance regarding mosquito-breeding sites and much of the education focuses on habitat reduction and management in urban areas. Ray Eidem is works with a member of the Fairfax County Department of Public Works on designing a strategy to deal with mosquitoes in their jurisdiction, which will include mosquitoes that may utilize BMPs for breeding. Roy Eidem suggested that VBDS contact Scott St.Clair, with the Fairfax County Department of Public Works, for information on stormwater BMPs.

Fairfax County Public Works and Environmental Services Department.

Scott St.Clair, the director of the Maintenance and Stormwater Management Division, was contacted by phone on April 17, 2001. He provided VBDS with copies of BMP plans used in Fairfax County from the Fairfax County Public Facilities Manual and mentioned that the entire manual was available for purchase.

Summary of the phone conversation with Scott St.Clair. Fairfax County has thousands of BMPs for both water quality and for volume reduction, and Public Works and Environmental Services Department is responsible for a large percentage of them. The reason for many of the BMP structures in this county is because about 1/3 of the Fairfax County water runoff drains into the Accoquam Watershed which is the main drinking water supply.

Fairfax County Public Works and Environmental Services Department is responsible for maintenance of approximately 10 major lakes, 600 water quality BMPs, 300 volume reduction facilities, and 35,000 manholes. In addition, the County has approximately 1600 privately owned and operated facilities in commercial and residential areas. These can include sand filters, extended detention basins (EDB), ponds, and others. The County provides inspections of private facilities approximately every 5 years and then they will provide a punch list that need to be addressed by the owner if there are problems or maintenance issues.

EDBs are essentially the only accepted BMP for urban areas. Public Works has learned that having multiple small orifices for draining down the facilities requires too much maintenance. They have changed to the use of a single, larger opening, based on the size of the EDB, surrounded by a debris screen. This design is much less prone to clogging and thus requires far less maintenance. The debris screen is generally designed with holes 1/4 the size of the main drainage orifice.

The County has recently been hit with many concerns regarding mosquito production, especially since last year with the discovery of a local bird infected with West Nile Virus. Much of Fairfax County is in a coastal grade (stream grades can be as low at 0.25%) resulting in thousands of acres of wetlands. As a result, there are numerous areas for mosquito breeding in and around urban areas. In addition, the "Asian Tiger Mosquito", *Ae. albopictus*, the primary vector of dengue hemorrhagic fever,

is common in small containers in urban areas. However, Scott St.Clair did not know the extent of mosquito breeding in BMP structures.

City of Alexandria Health Department. Joe Fiander, one of the primary "mosquito people" for the Division of Environmental Health, was contacted by phone on April 17, 2001.

Summary of the phone conversation with Joe Fiander. Joe Fiander is employed by the State of Virginia, but is assigned to the City of Alexandria. The City had a mosquito program in the past, but it was eliminated due to budget cuts. With the presence of West Nile Virus in the area, a new vector control program may become established. Currently, the Health Department is starting a trapping program to determine what mosquito species are present in the area. This includes adult trapping, dead bird collections and testing, larval sampling, and larviciding. For larviciding, the City uses microbial larvicides (Bti and Bs), the insect growth regulator methoprene, and Agnique, a monomolecular film used for controlling 4th instars and pupae. Agnique is non toxic and does not even have an MSDS sheet.

Most BMPs in the old part of the city are below ground structures. Joe Fiander has not surveyed these structures as of yet, but he will be investigating them in the near future for possible vector production. In the newer areas of the city, primarily in the western regions, retention ponds are built into new housing developments. Many of these retention ponds are supposed to drain in 72 hours or less, but they frequently retain water for much longer periods and become a source of mosquitoes. The city has big problems with the "Asian Tiger" mosquito, *Ae. albopictus*, that breeds in urban containers.

City of Alexandria, Department of Transportation and Environmental Services. Bill Hicks, the watershed program administrator for the Division of Environmental Quality, was contacted by phone on April 19, 2001.

Summary of the phone conversation with Bill Hicks. The City of Alexandria is essentially 100% built out. When BMP issues began for stormwater runoff, there was little room to build large outdoor structures, thus almost all BMPs are built below ground.

In general, stormwater runoff will pass through some kind of filter prior to entering the main storm sewer. Most BMPs are small-scale and most are manufactured hydrodynamic structures such as Stormceptor, Baysaver, etc. Other underground BMPs include Austin sand filters and DC sand filters (developed in the District of Columbia). Almost all of these structures are privately owned and operated. The developer will put the units into the construction plans, and then the owner is responsible for upkeep and maintenance. Many owners opt to make contracts with a contractor for maintenance. There are a few regional ponds, mostly associated with newer housing tracts. The maintenance of these structures generally become the responsibility of homeowners associations.

Because of the scale of the stormwater program in the city, Alexandria is investigating the possibility of developing a "Stormwater Utility" department that would be responsible for all things related to stormwater including water quality, water quantity, BMP implementation, BMP maintenance, etc. In the opinion of Bill Hicks, this is probably the inevitable solution.

New BMP technology is focused on implementation of bioretention devices. Bioretention devices were developed in Prince Georges County, MD, and are very effective at removing metals from incoming water, usually through the use of mulch in a depression. These devices usually include vegetation, but are not necessarily heavily planted since the mulch is the main filtering device. Biofiltration basins are designed in areas with soils that allow infiltration, which is the preferred method, and generally drain down quickly. In areas with impervious clay soils, bioretention filters are built which function on the same principle, but have perforated PVC pipes buried below ground to allow drainage through the mulch filter.

Bill Hicks expects that the City will be more observant of mosquitoes in their BMP designs this year and in the future due to the presence of West Nile Virus in the area.

WISCONSIN

Summary. VBDS investigated BMP / vector issues in Wisconsin, with particular interest in the areas in and around Madison and Milwaukee. LaCrosse County Health Department, Vector Control (<http://www.co.la-crosse.wi.us/health.htm>) is responsible for mosquito surveillance and control in 8 surrounding Counties, 2 of which are in Minnesota. The emphasis of the program is on *Ae. triseriatus*, a container breeding/ tree hole mosquito, and the primary vector of LaCrosse encephalitis virus in the region. Wisconsin has a web site that provides contact information for their local public health departments statewide (www.dhfs.state.wi.us/dph_ops/lhdl.htm). The cities of Milwaukee and Madison do not have active vector control programs. Vector control in Milwaukee is conducted by the Milwaukee Department of Neighborhood Services, Nuisance Control (<http://www.ci.mil.wi.us/citygov/dns/home.htm>) on a complaint basis only. Vector control in Madison is conducted by the Madison Department of Public Health, Environmental Protection (<http://www.ci.madison.wi.us/health/mdph.html>), on a complaint basis only.

The Wisconsin Department of Commerce, Safety and Buildings division, Plumbing Program (<http://commerce.state.wi.us/SB/SB-PlumbingProgram.html>) provides plumbing consultation, inspection, plan review, and product review services. This agency is involved with BMP design and implementation in Wisconsin, and is currently preparing documents for the Wisconsin Department of Natural Resources (WDNR) on the subject. Additional information on stormwater and BMP structures in Wisconsin can be found on the WDNR Internet site (<http://www.dnr.state.wi.us/org/land/forestry/usesof/bmp/bmpsourcesforhelp.htm>) and on the University of Wisconsin Extension, Water Resources Program Internet site (<http://clean-water.uwex.edu/index.html>).

The City of Milwaukee, Department of Public Works (<http://www.mpw.net/>) and the City of Madison, Department of Public Works, Engineering Division (<http://www.ci.madison.wi.us/engineering/>) both design, implement, and maintain a large percentage of stormwater BMPs in their areas.

Wisconsin Department of Commerce. Lynita Docken, the Plumbing Program manager for the Program Development Bureau, Safety and Buildings Division, was contacted by phone on March 12, 2001.

Summary of the phone conversation with Lynita Docken. The Safety and Buildings division provides plumbing consultation, inspection, plan review, and product review services. The division administers certifications, licenses, and registrations of individuals engaged in plumbing. Lynita Docken was very familiar with BMPs as well as vector issues. She was currently in the process of revising plumbing rules for the State and she was serving on two Wisconsin Department of Natural Resources (WDNR) groups, one focused on stormwater and the other on erosion control (WDNR acts as the EPA for the State and issues NPDES permits). She, and a team of people, were currently in the process of preparing a state BMP manual for infiltration devices.

Lynita Docken was in the process of writing a report to DNR regarding state comments on the stormwater requirement code with regards to vectors and requested a copy of the VBDS out-of-state report to use as a citation. She was having great difficulty in finding any available information on vectors associated with structural BMPs. The goal is to have vector issues addressed by WDNR before they prepare the rules for NPDES, Phase II, which will require water runoff treatment from land of 1 acre or less. Apparently, constructed wetlands have produced vector species and some current designs have been built "with no surface water" in an attempt to eliminate the problem.

Lynita Docken suggested that VBDS contact Dick Otis, an on-site wastewater specialist working for Ayers and Associates, in Madison, and Robert Thibolodeaux, with the Wisconsin Department of Health.

LaCrosse County Health Department. Dave Geske, who runs the Vector Control program, was contacted by phone on December 15, 2000.

Summary of the phone conversation with Dave Geske. David Geske works in 8 surrounding Counties, 2 of which are in Minnesota. His emphasis is on surveillance and control of *Ae. triseriatus*, a container breeding/ tree hole mosquito, and the primary vector of LaCrosse encephalitis virus in the region. This species is generally not

associated with stormwater structures in the region; however, there are approximately 26 species of mosquitoes in his area that he may deal with.

The counties that Dave Geske works in contain many tributaries of the Mississippi River that create marsh complexes suitable for mosquito production. In general, most of his work does not include water resulting from stormwater runoff. Some of the holding ponds he has experienced, especially those located in lowlands, produce large numbers of *Ae. vexans* along the edges. This aggressive species of mosquito is responsible for numerous complaints in the urban and suburban regions. Some new developments are required to install retention ponds that have also resulted in the production of *Ae. vexans*, as have drainage areas along interstates in the metropolitan areas. Pammel Creek, a concrete channel that runs through LaCrosse, occasionally has problems with water ponding at the outlet due to silt buildup, creating mosquito habitat. *Cx. pipiens* mosquitoes are occasionally caught in adult traps, but larvae are found infrequently.

Dave Geske suggested that VBDS contact Pat Caffrey, with the City of LaCrosse Public Works Department, and Lynita Docken, with the Wisconsin Department of Commerce. Lynita Docken works with pollutants and wastewater and has contacted Dave Geske in the past to discuss potential vector issues associated with the construction of water management structures.

City of LaCrosse Department of Public Works. Pat Caffery was contacted by phone on Jan 30, 2001.

Summary of the phone conversation with Pat Caffery. Pat Caffery had not considered vector issues associated with stormwater systems, but had a good understanding of vectors such as mosquitoes and rodents. The Public Works Department is responsible for a variety of city services including streets, sewer, water runoff, erosion control, as well as the Pammel Creek system. Pammel Creek is a large drainage channel that receives stormwater runoff. Pat Caffery was not aware of any vector problems associated with this channel and he stated that the water is usually not stagnant, but flowing.

Pat Caffery was very familiar with BMP structures (i.e. wet ponds, dry ponds, etc.). In Wisconsin, cities with > 100,000 people, such as Madison and Milwaukee, are well into implementing "Phase I" of the EPA's water quality program. These cities were mandated to build different BMP's and were monitoring them for contaminant removal performance. Pat Caffery suggested that VBDS contact Public Works in Madison and Milwaukee.

Milwaukee Department of Neighborhood Services. Don Schaewe, with Nuisance Control, was contacted by phone on Oct 31, 2000.

Summary of the phone conversation with Don Schaewe. The city of Milwaukee does not have an active vector control program; however, vectors are abated by Nuisance Control in response to public complaints. All stormwater in the city is routed into underground sewer systems called the "Deep Tunnel Project" from where it is then treated. Don Schaewe suggested that VBDS contact the Milwaukee Metropolitan Sewage District for more information on stormwater issues.

City of Milwaukee, Department of Public Works. Tim Thur, a civil engineer, was contacted by phone on Feb 1, 2001.

Summary of the phone conversation with Tim Thur. Tim Thur was very familiar with BMP's and stormwater management. Many BMP structures have been built in and around Milwaukee, some by private developers and some by the Public Works Department. Those built by developers are reviewed by the City and inspected at different phases during construction. Some of the BMP types found in the area include retention and detention basins, whirlpool type units such as Vortech and Stormceptor, and "roof storage" where water flow is restricted from commercial flat roofs, essentially turning them into extended detention / sedimentation basins.

Citizens of Milwaukee and the surrounding areas frequently voice concern with potential mosquito problems and children drowning in new pond constructions. Ponds have to be built with a shallow grade of approximately 20 ft, followed by a "safety shelf" before dropping into deep water. Tim Thur was not aware of mosquito problems following the construction of ponds.

Privately maintained BMPs, especially extended detention basins, frequently become choked with tall grass and vegetation overgrowth, which is a problem that needs to be enforced. Tim Thur mentioned that maintenance issues such as this are always a concern and that he would like to see more frequent maintenance; however, most stormwater management structures are maintained infrequently. For example, catch basins are on a 3-year cleaning cycle.

Madison Department of Public Health. Doug Voegeli, the supervisor of Environmental Protection, was contacted by phone on December 20, 2000.

Summary of phone conversation with Doug Voegeli. The City of Madison has no organized vector control program. The Madison Department of Public Health, Environmental Health will respond to vector problems on a complaint basis only. Additionally, they are also involved with issuing discharge permits for water (e.g. pool draining, manufacturing plants, etc.). Doug Voegeli suggested that VBDS contact the Madison Neighborhood Plan Review, the Madison Public Works Department, and the Madison Sewer Utility.

City of Madison Department of Public Works. Jeff Benedict, a civil engineer with the Engineering Division, was contacted by phone on Jan 31, 2001.

Summary of the phone conversation with Jeff Benedict. Jeff Benedict was very knowledgeable on BMPs and stormwater runoff issues. He has been involved with stormwater and other runoff issues for many years and has designed, constructed, and retrofitted BMPs in and around the city. Madison has a multitude of BMP types including wet ponds, extended detention basins (EDB), and Stormceptors. Retention (wet) basins are used to collect runoff and preserve water quality and are mandated for any construction area of 80 acres or more. EDBs are also common, but used more frequently for flood control. Stormceptors require frequent maintenance and when possible, Public Works prefers devices that require less maintenance, for example, a pond that required dredging only every 10-20 years.

Lack of maintenance in BMP structures is a big issue. The initial cost of BMP construction is insignificant compared to the huge financial burden involved in the

maintenance of structures. Any development of 3 acres or more has to provide some form of stormwater detention in Madison; however, the developer can appeal this, and if approved, pay a one-time fee to Public Works. The fee would then be used to help fund larger projects in more critical areas. Currently, the big push in Madison for construction site erosion control.

Jeff Benedict was very knowledgeable of mosquito biology. He and his colleagues have done background research on mosquitoes. He noted that EDBs produce many more mosquitoes than permanent wet ponds. In fact, it is Jeff Benedict's opinion that retrofitting wet ponds in for dry ones can reduce mosquito problems in Madison; however, he also acknowledged that the wet ponds can be conducive to mosquito production and vegetation overgrowth because the perimeter shore has to be built with a 1-2% grade for safety. This results in water only 1 foot deep at 10 feet out from the shore. In general, mosquitoes are considered a "non-factor" in the construction of wet ponds. Jeff Benedict also noted that new homes built around wet ponds sell for more money in new developments, but residents generally protest the retrofitting of ponds into existing developments.

Conclusions

One of the most important lessons learned from this study was recognition of the overall number of government agencies involved with various aspects of stormwater runoff management. VBDS could have spent many additional months exploring stormwater issues within each state by contacting other agencies and interacting with other employees with varied backgrounds and specialties. Considering this, it should be noted that this report provides only a small overview of the overall situation.

Due to the size and scope of the nationwide programs aimed at managing and "cleaning" stormwater runoff, it is clear that vector issues must be addressed. It is important to realize that the innumerable constructed and planned structural BMP devices across the country will provide new habitat for vector production. This may result in an increase in the number of local vector species and may provide habitat for exotic species to become established. Several agencies in Maryland, New Jersey, and Virginia related that the rapid spread of West Nile Virus, transmitted by anthropophilic mosquitoes, is causing some to reconsider BMP strategies. Even if individual BMP structures only produce relatively small number of vectors, even infrequently, the cumulative impact will be compounded by the potentially large number of breeding sites available. Managing vectors in these created habitats is an urgent need. Rapid construction and poor interagency communication places an increasing burden upon vector control agencies.

In addition to the question of how to best manage vectors in the potentially large number of BMP structures, it is also evident from this study that operation and maintenance plans for many of these structures have yet to be thoroughly examined. "Crisis management" is the current maintenance paradigm used by various agencies including the Minnesota Department of Transportation and the Austin Watershed Protection & Development Review Department. This paradigm is probably the most common means used by other agencies based on the fact that many of these structures were reported as infrequently, irregularly, or never maintained. This is not a suitable solution, as regular maintenance is needed to preserve the intended level of BMP performance while reducing or eliminating the production of vectors. Contacts from the

Minnesota Department of Transportation, the Virginia Transportation Research Council, and the Virginia Department of Conservation & Recreation have evidence that shows a lack of regular maintenance can result in re-suspension of pollutants and effective wash-outs from structures. As suggested by the Alexandria Department of Transportation and Environmental Services, it seems inevitable that some kind of "Stormwater Utility" department be established in order to regularly manage and maintain BMPs. The initial costs of structural BMP construction are insignificant when compared to the financial burdens caused by regular maintenance.

The fact that agencies have differing opinions on which structures are most appropriate illustrates the fact that BMPs are constructed at rates exceeding the agencies' understanding of the long-term implications of these new BMPs. Several agencies are encouraging the use of non-structural BMPs that provide performance similar to that of structural BMPs, while reducing cost and maintenance. It is evident that the performance of existing structures cannot easily be evaluated and the long-term water quality benefits remain questionable.

This study provided a wealth of information on both BMP structures and associated vector issues in widely-separated areas of the United States. When considering the results of the out-of-state studies conducted by VBDS, there is no question that BMP structures can provide suitable habitats for vectors, with both local and exotic vector species utilizing them for reproduction. At this time, any resulting public health concerns are still poorly understood but, this study clearly demonstrates the need for communication and collaboration between agencies and states, particularly between those interested in water quality and vector control. Vector control agencies should be consulted to:

- provide input on design improvement
- ensure compliance with state health and safety codes
- minimize vector production and associated surveillance and control costs.

Biologists and engineers should strive to compliment each other, as modeled by the Somerset County Public Works Department.

APPENDIX A:

Contacted Agencies

COLORADO

Colorado Department of Public Health and Environment
Consumer Protection
Vector Control
Dale Tanda, Program Manager
4300 Cherry Creek Drive South
Denver, CO 80246-1530
(303) 692-3631 Dale
(303) 692-3654 Main
dale.tanda@state.co.us

City and County of Denver
Department of Environmental Health
Division of Animal Control
Vector Control
Diane Milholin, Inspector
666 S. Jason St.
Denver, CO 80223
(303) 698-5553 Diane
(303) 698-4959 FAX
milhobd@ci.denver.co.us

Colorado Mosquito Control
Michael McGinnis, President
9999 Old Wadsworth Blvd.
Broomfield, CO 80021
(303) 466-4515
(303) 466-1522 FAX
comosq@aol.com

City and County of Denver
Neighborhood Inspection Services
Community Planning and Development
Greg McKnight
200 W 140th Ave, Suite 304
Denver, CO 80223
(720) 865-3209 Office
(720) 865-3287 FAX
(303) 607-7416 Pager

Tri-County Health Department
Vector Control Program
Monte Deatrich, Supervisor
4301 E. 72 Ave.
Commerce City, CO 80022
(303) 288-6816 Main
(303) 287-9678 FAX
(303) 227-4012 Direct

MARYLAND

Maryland Department of Agriculture
Office of Plant Industries and Pest Management
Mosquito Control Section
Cyrus Lesser (Entomologist & head of mosq. section)
50 Harry S. Truman Parkway
Annapolis, MD 21401
(410) 841-5880 main
(410) 841-5870 Cyrus
lessercr@mda.state.md.us

Maryland Department of Agriculture
Office of Plant Industries and Pest Management
Mosquito Control Section
Mike Cantwell, west Maryland regional entomologist
6701 Lafayette Ave.
Riverdale, MD 20737
(310) 927-8357
skeetermd@erols.com

Calvert County Mosquito Control Program
Wilson Freeland, supervisor
175 Main Street
Prince Frederic, MD 20678
(410) 535-6924
freelavw@co.cal.md.us

Frederick County Health Department
Environmental Health Services
Mosquito Program
Tom Mohler, manager
350 Montevue Ln.
Frederick, MD 21702
(301) 631-3160 Tom
(301) 694-1029 main
tmohler@fredco-md.net

Maryland Department of Transportation
State Highway Administration
Highway Hydraulics Division
Doug Rose, chief engineer
Steve Udinski, engineer
707 North Calvert Street, MS C-201
Baltimore, MD 21202
(410) 545-0361 Doug
(410) 545-8405 Steve
sudzinski@sha.state.md.us

Maryland Department of the Environment
Water Management Administration
Non-Point Source Program
Ken Pensyl, Program Manager
Stewart Comstock
2500 Broening Highway
Baltimore, MD 21224
(410) 631-3543 Main
(410) 631-3561 Ken
(410) 631-3550 Stewart
scomstock@mde.state.md.us

MINNESOTA

Minnesota Department of Natural Resources
Waters, Central Office
John Stine
500 Lafayette Road
St. Paul, MN 55155-4032
(651) 296-4800 main
(651) 296-0440 John

Minnesota Pollution Control Agency
Policy and Planning Division
Community and Area-wide Programs Section
Water Unit 2
Don Jakes, unit supervisor
520 Lafayette Rd North
St. Paul, MN 55155-4194
(651) 296-7786
donald.jakes@pca.state.mn.us

Minnesota Department of Transportation
Office of Environmental Services
Greg Busacker, aquatic biologist
Dwayne Stenlund, soil ecologist
395 John Ireland Blvd.
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Metro Counties Government Center
JoE Sanzone, Director
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APPENDIX B:

Summary Report of a Visit to Portland, Oregon

Exploring Structural Best Management Practices for Treating Stormwater Surface Runoff outside California

Summary of a Visit to Portland, Oregon

Introduction

For the past year, the California Department of Health Services, Vector-Borne Disease Section (VBDS) has been gathering information on vector issues associated with structural Best Management Practices (BMP) for surface water runoff built outside the state of California. The primary purpose of this study was to develop a better understanding of the vector problems and solutions associated with different structural BMPs from vector control agencies. However, it also was intended to provide opinions and attitudes of vector control personnel toward the construction of these BMP structures and an indication of their abundance and distribution. As a direct result of the report based on this study, VBDS was asked to further explore vector issues associated with structural BMPs in specifically chosen cities and states known to have actively addressed surface water runoff through the use of BMPs.

This addendum to the original study is not limited to vector control agencies, but also includes other agencies involved with stormwater and/or local NPDES permits. For consistency, the same questionnaire was used to gather information; however, the study also includes summaries of telephone conversations and other information obtained. To further validate this study, VBDS was asked to travel out-of-state to gain further experience and make visual assessments of BMP structures.

Many government agencies within Oregon have implemented Best Management Practices (BMP) for treating surface stormwater runoff in compliance with local NPDES permits. VBDS organized a two-day trip to meet with representatives from several local Portland agencies involved with vectors and/or NPDES permits for stormwater runoff. On March 6-7, 2001, Marco Metzger, a public health biologist with VBDS, was accompanied on this trip by Dean Messer, a stormwater consultant with Larry Walker Associates, and Catherine Beitia, an environmental specialist with California State University, Sacramento. The purpose of this trip was to discuss and visit different structural BMPs, with particular interest in understanding design and maintenance factors that could influence vector production. The trip itinerary included meetings with personnel representing three government agencies and taking tours of structures in and around the city.

March 6th
Oregon Department of Transportation Meeting and Tour

We met with Jeff Moore and Paul Wirfs of the Oregon Department of Transportation (ODOT) offices in downtown Portland on the morning of March 6th and were later accompanied on a tour of 7 representative structural BMPs. Jeff Moore is the environmental program coordinator for the ODOT Clean Water Unit, and he assists with the coordination of their NPDES permit. ODOT operates independently, maintaining their own statewide NPDES permit. Paul Wirfs is a civil engineer involved with designing ODOT water quality structures. ODOT has their own BMP handbook available on the Internet (www.odot.state.or.us) under the subheading, "Environment", *Road Maintenance Water Quality & Habitat Guide*.

Portland has a long history associated with water quality issues and BMPs. The Tualatin River in Washington Co. was among the first water bodies in the United States to have a Total Maximum Daily Load (TMDL) assigned to it, specifically for phosphorous content. The river has since been reassessed and additional TMDLs have been added. Because of this, Washington Co. has a large number of structural BMPs designed to reduce the quantity of pollutants released into the river.

ODOT have gained much valuable experience in the past 5 years in understanding how different stormwater BMPs perform. They have been gradually moving away from the use of wet ponds for water quality because of their high maintenance needs and the difficulty in thoroughly removing all contaminated sediments. In addition, invasive cattails need to be managed periodically. The last wet pond "clean out" performed by ODOT was 3-4 years ago due primarily to a bacterial bloom in the water, not necessarily because the pond was ready for sediment removal. ODOT is opting for BMP structures that are easier to maintain such as swales.

In addition to maintenance issues associated with wet ponds, many areas of Portland have fine clay soils that once suspended in water take weeks or months to settle out. This reduces the efficacy of many structural BMPs for pollutant removal. Many of ODOT's newer BMPs do not involve structures, but rather are changes in procedures and protocols to reduce the quantity of pollutants in stormwater runoff. In

situations where structures must be built, ODOT suggests that designs have better access, using reinforced concrete for ramps and in any other parts of the structure where heavy equipment might need to be used for maintenance purposes. Their experience with structures that were built using shot-crete was severe damage and cracking to the structure by heavy maintenance equipment, sometimes after only one visit.

Jeff Moore was aware of vector issues associated with standing bodies of water; however ODOT does not currently contribute resources to Multnomah County Health Department, Vector Control (MCVC) for surveillance and abatement of mosquitoes within ODOT BMP structures. MCVC uses County funds to perform routine mosquito surveillance and control in many ODOT structures in Multnomah Co., particularly the permanent water hazardous material (Haz-Mat) containment ponds and wet basins. ODOT structures in Washington Co. are not abated by MCVC. Only ODOT Site #1 (listed below) receives mosquito control. Other BMPs included in the ODOT tour may be utilized by vector species, but their significance remains unknown.

The all-day tour examined locations in both Multnomah Co. and Washington Co. The following list provides a short summary of each site and images of structures of particular interest. Location maps follow the list.

Site #1. Airport Way and Interstate 205 interchange Haz-Mat Pond.

This site was built to contain hazardous material spills from the adjacent roadways in the event of an accident. Although it was not built to address water quality issues, ODOT felt that it provided some important lessons learned that apply to any purpose-built water quality improvement pond. ODOT's main concerns with this structure were with maintenance and access, and they felt these issues should be considered in the design and construction of future structures. This structure has no provisions to allow it to be drained for maintenance procedures. There is no access road and getting maintenance equipment into the structure and then into the tight, winding channels for clean out is difficult. In addition, this structure was built with a heavy plastic liner that has slowly been settling and causing the sides of the structure to start subsiding. This structure holds water year-round, grows thick stands of cattails,

and is a source of mosquitoes, particularly *Culex tarsalis* and *Anopheles punctipennis*. MCVC does routine mosquito surveillance and control at this site every 3-4 weeks from approximately July to October, the peak season for these mosquito species.



Site #2. Ross Island Bridge (northwest) CDS / Extended Dry Detention Basin.

This unit was less than one year old. It was designed to receive stormwater runoff from road surfaces on the western sloping half of the Ross Island Bridge. Water is first directed through an underground CDS unit to remove heavy sediments before being discharged into the basin. The basin is provisioned with a concrete access pad for maintenance equipment. It was noted that the drainage outflows held standing water because they were designed with sumps. It was also noted that large sized "rip rap" at the bottom of the basin could create potential mosquito breeding habitat such as that experienced at the Caltrans Sorrento Valley EDB site in San Diego County.

Site #3. Trimet Park & Ride Infiltration Trench.

This unit was not owned and operated by ODOT, but rather by Trimet, the Portland agency that runs the local buses and lightrail trains. It was designed to receive water runoff from the parking lot. It was not noted if in-line catch basins or other structures served as prefilters to the water before being released onto the surface of the

infiltration trench. However, there was evidence suggesting that water had been flowing over the trench rather than into it; the surface of the trench was clogged with sediment and moss.

Site #4. Boones Ferry Road Bioswale.

This bioswale received surface water runoff from Boones Ferry Rd as well as from an adjacent parking lot. The original plans called for incorporating several flow spreaders along the length of the structure to keep the water evenly distributed across the swale. The construction crew misinterpreted the plans and raised several rock dams in place of flow spreaders. As a result, water ponds behind each dam and may sit for periods of time. In addition, this has also resulted in the accumulation of pockets of sediment.



Site #5. Beaverton-Tigard Hwy & Greenburg Rd Extended Dry Detention Basin.

This structure receives surface water runoff from the adjacent intersection. It was designed as a dry pond, with the bottom of the basin lowered approximately 6 inches below the outlet to increase the time interval between clean outs. However, lowering the basin floor resulted in the creation of a permanent pond of water.



Site #6. Tualatin MAX station Park & Ride Extended Dry Detention Basin.

BMP designers were given a very small area in which they were required to build a water quality basin for treating surface water runoff from the MAX station Park & Ride lot as well as from the parking lot of the nearby apartment complex. The result is a deep basin with steep sides to accommodate the large volumes of incoming water. There is no access ramp into the basin for maintenance equipment.



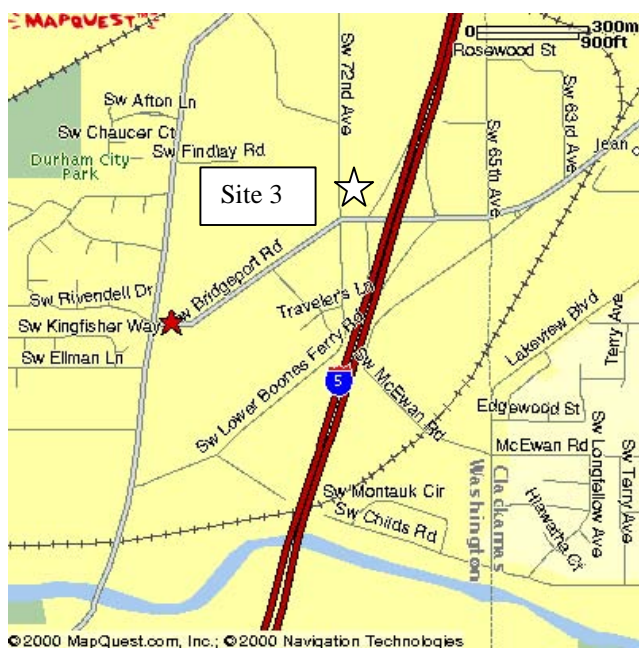
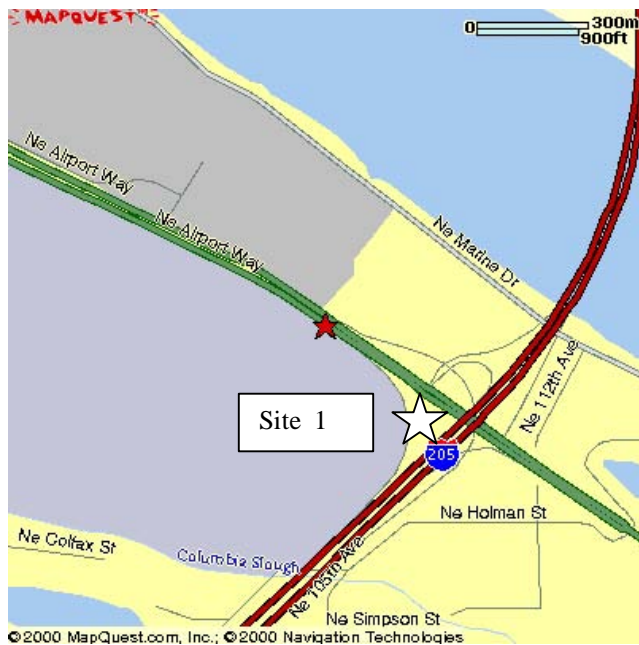
Site #7. Orenco MAX station Park & Ride Extended Dry Detention Basin.

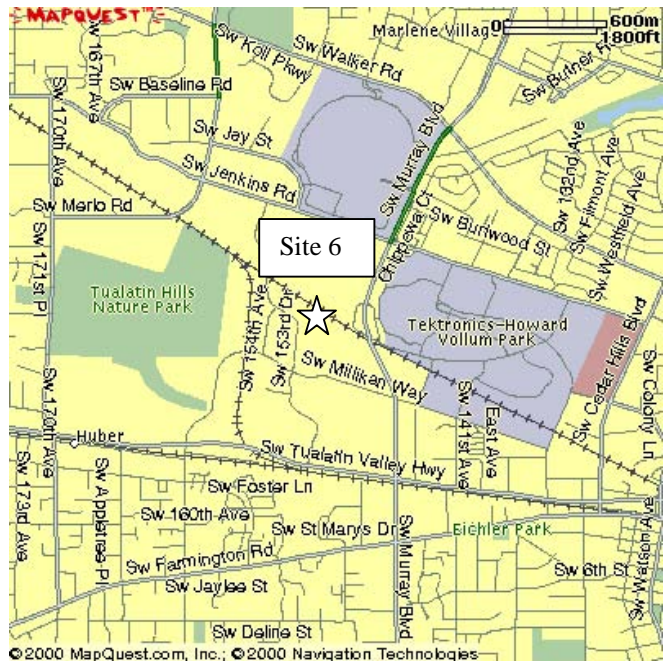
This structure was designed and built for treating surface water runoff from the MAX station Park & Ride lot. It is relatively new and incorporates a unique design with a long, narrow channel that partially surrounds the parking lot and functions as an extended detention basin. The inlet into the basin is only a few feet from the outlet; however, as water enters it is forced to back up in the long narrow basin.

March 6th, ODOT Tour Regional Map with BMP Site Locations



March 6th, ODOT Tour Site Location Maps





March 7th

Multnomah County Health Department, Vector Control & City of Portland, Bureau of Environmental Services Meeting and Tour

We met with David Turner, Chris Wirth, and Katie Bretsch on the morning of March 7th. David Turner is the mosquito control field supervisor and Chris Wirth is the supervisor for the vector control program. Katie Bretsch is the manager of the Collections Systems Operations and Maintenance program for the City of Portland, Bureau of Environmental Services (BES).

City of Portland, Bureau of Environmental Services. BES is one of four City bureaus. They manage the municipal NPDES permit for the City and include the Port of Portland and Multnomah County as co-permittees. BES has their own BMP manual (www.enviro.ci.portland.or.us/swp.htm) that provides information on all aspects of the city's stormwater program. Katie Bretsch is primarily responsible for stormwater BMP designs, their maintenance, and current operations. She specifically works with those that are built by BES for stormwater management, or for any stormwater runoff from the public right-of-way (i.e. culverts, road-side drains). BES has a \$22 million dollar annual budget for water quality issues. The mission of BES is protection of both surface and ground waters, while putting strong value on multi-objective management, and a very high value on protecting endangered and non-target species. BES has been using the Endangered Species Act (ESA) as leverage to push the program forward, especially as it relates to endangered fish such as salmon that utilize local waterways. One of BES' future goals includes the development of a "Green Streets Program" to create stormwater-management-friendly streets in residential areas.

BES currently operates 9,210 sumps and 6,507 sedimentation manholes, and over 90 stormwater facilities that could hold open, standing water. BES views the spraying for mosquitoes as having been successful for control in their open water areas. The cost involved is not viewed as excessive by BES standards, and the cost-per-acre is not unreasonable. If it is a question of spraying vs. redesign of a stormwater structure such as an open pond, BES will opt to spray. MCVC has asked BES to redesign ponds

(i.e. no vegetated perimeters of ponds and water margins), however, BES has been reluctant to do this because it could reduce the ability of ponds to remove pollutants.

Multnomah County Health Department, Vector Control. Currently, there is no State vector control program in Oregon. MCVC is responsible for mosquito surveillance and control throughout Multnomah Co., and has a small contract area with the City of Durham in Washington Co. (3.6 square miles). This small agency has only 6 full-time staff and is badly understaffed for the extensive control of mosquitoes and rats that includes a cumulative area of approximately 1000 acres yearly. The active mosquito control treatment program runs from January through September.

MCVC works on lands owned and/or managed by several different agencies including BES, the Port of Portland, ODOT, East Multnomah County Drainage District (EMCDD), and the Portland Transportation Department (PTD) for mosquito surveillance and control. BES funds a large part of the city's rodent sewer baiting program; however, BES is reluctant to acknowledge that some of their facilities and structures (e.g. sedimentation manholes and sumps) create public health threats / nuisance by producing large numbers of mosquitoes. BES contributes approximately \$20,000 annually for mosquito control. The Port of Portland provides sufficient financial support to MCVC for mosquito control in their mitigation wetlands sites. ODOT, EMCDD, and PTD do not contribute funds for vector control within their jurisdictions.

MCVC would like to see better communication between agencies. They are often not informed of the development of new sites until a problem arises or after structures are already built. MCVC would like to be involved in the design review and permitting process to reduce the potential of vector production. Accurate maps of facility locations as well as a description of the hydrology should be provided. MCVC recommendations would include building structures with steep sides and hand removal of vegetation on a regular basis. In addition, access ramps for boats would need to be included in the design of large structures and roads around smaller structures. The problem MCVC sees with the creation of new sites is that they require continuous vegetation maintenance and vector surveillance and control. They note that there are

ever increasing numbers of structures for the limited staff. In addition, MCVC has noted that once construction is complete there is very limited maintenance of these structures.

Rodents. In the Willamette Valley nutria rats and beaver can create drainage problems. These rodents frequently dam culverts and ponds causing water to stand longer and at higher level than anticipated. MCVC often removes beaver and nutria dams to restore proper water flow and may contract with local trappers to remove problem animals.

Mosquitoes. Mosquito control is done for both nuisance control and for disease prevention and control. There are 7 species of mosquitoes that are of particular importance in the Portland area that are regularly abated by MCVC. Larvicides are the only chemical compounds used for routine control. Large sites are treated by helicopter with contract companies. Mosquito fish can be used, but only in closed systems where it is not possible for them to get into natural waterways. Adulticiding in Multnomah County is restricted to a health emergency. The following list briefly summarizes the importance of each species and the approximate number of sites abated by Vector Control.

1) *Aedes washinoi* is a winter mosquito associated with seasonally flooded rain pools and ponds.. Breeding sites may be as small as 30 ft² to over 50 acres in size. They have only one generation per year, generally emerging as adults in mid-March. MCVC treats about 250 sites, mostly in neighborhoods and urban areas.

2) *Aedes vexans* and *Ae. sticticus* are floodwater mosquitoes. In the Portland area, these species primarily utilize the coastal floodplains and wetlands of the Columbia and Willamette rivers. They are generally found between April and mid-June. MCVC treats approximately 125 sites, most very large (150+ acres), by contract aerial larviciding.

3) *Coquillettidia perturbans* has a unique biology that makes them difficult to control. Larvae of this species attach to the roots of aquatic plants where they remain throughout their development. Larvae develop slowly starting in late fall and adults

emerge in early July. In the Portland area this species is only associated with cattail marshes and there is only one generation per year. The only effective control is to apply methoprene pellets (Altosid) at least 3 consecutive times. MCV C does not have the budget required to effectively control this species.

4) *Culex tarsalis* and *Anopheles punctipennis* are summer and fall species that utilize open bodies of water, especially year-round ponds. They are generally present between early July and October, with two characteristic population spikes, one in early July and the other in early September. MCV C treats approximately 800 sites every 3-4 weeks during peak season.

5) *Culex pipiens* is a polluted water mosquito. It is less common than *Cx. tarsalis* and has been found associated almost exclusively with polluted bodies of water. It will utilize underground sedimentation manholes and is common in the City's wastewater treatment plant. The sites treated for *Cx. tarsalis* and *An. punctipennis* listed above are all potential breeding sites for this species. Approximately 20 sites are recognized as producing large numbers of this species. The seasonality and control of *Cx. pipiens* mirrors that of *Cx. tarsalis*.

The tour visited 11 sites within northern Multnomah Co., most located in the vicinity of the Columbia River. MCV C does regular mosquito surveillance and control at all of the sites, except for the BES bioswale, Site #3. The following list provides a short summary of each site visited with images of structures of particular interest. Location maps follow the list.

Site #1. Ramsey Lake Stormwater Detention Facility.

This facility is one of the largest that we visited during the tour. It was designed to receive stormwater runoff from many acres of the surrounding industrial area. Water flows initially into a large concrete sedimentation basin. This basin can be drained for maintenance and has ramps leading into it from where a front-loader tractor can be driven in. From the sedimentation basin, water is directed into a large central pond from where it exits via a canal into the Columbia slough. The entire facility holds water year-round.

The facility itself is managed solely by BES; however, adjacent to this site is a seasonally flooded mitigation wetland area managed by the Port of Portland. MCVC abates a variety of mosquito species in this area. Floodwater mosquitoes are a regular problem in the mitigation wetland area, whereas *Culex tarsalis* and *Anopheles punctipennis* utilize the stormwater facility, particularly the central pond. Mosquito control at the stormwater facility is done exclusively by ground spraying. Mosquito fish can not be planted at this site because it empties directly into the Columbia slough. Beaver frequently dam the central pond creating drainage problems. A dam is visible in the second photo below.





Site #2. Sedimentation Manholes and Infiltration Sumps, University Park Site.

The City of Portland has 6,507 sedimentation manholes and 9,210 infiltration sumps. These units are designed to take stormwater runoff from residential streets and allow it to infiltrate into the ground (similar to a groundwater injection well). Water enters through an inlet grate, flows into a sedimentation chamber that is approximately 4 feet deep (similar in function to the Caltrans MCTT pre-filter sedimentation chamber), then passes into a perforated sump that is approximately 30 feet deep. In addition to trapping sediments and other pollutants, their purpose is to alleviate the water load in the storm drain system that can overflow into the sewer during periods of heavy rain, allowing raw sewage to be expelled into the rivers. According to BES, the average sedimentation manhole collects up to a yard of debris in one year. Maintenance (i.e. sediment removal) is scheduled only every 3-5 years. As a result, sedimentation chambers are frequently clogged with debris.

The manholes covering these structures have many circular openings that allow mosquitoes to access the water below. *Culex pipiens* larvae have been detected by MCVC from the sedimentation chambers and adults may utilize these structures to overwinter. MCVC has not yet monitored for mosquito larvae in the deep sumps. Water is present in these structures for many months.



Site #3. BES Water Pollution Control Laboratory, Bioswale.

These were test swales located at the BES Water Pollution Control Laboratory and consisted of two swales running parallel to one another. BES staff use this structure to obtain various data on swale performance such as pollutant removal efficiency and vegetation efficiency. It also receives some stormwater runoff from the BES parking lot.

Site #4. BES Water Pollution Control Laboratory, Water Quality Ornamental Pond.

This structure was built at the BES Water Pollution Control Laboratory to function as a water quality pond, receiving stormwater runoff from the surrounding neighborhood, while providing aesthetic value and a convenient study site. Aesthetically, this was without question one of the most pleasing BMPs to look at; however, it created excellent habitat for a variety of mosquitoes. The cattails provide habitat for *Coq. perturbans*, whereas *Culex tarsalis* and *Anopheles punctipennis* are regularly found in the pond. The center rip rap strip provides hundreds of microhabitats that are used by mosquito larvae (similar to the Caltrans Sorrento Valley EDB).



Site #5. Multnomah County Exposition Center Mitigation Wetlands.

This site is being built by the Port of Portland and is designed as a mitigation wetland habitat while functioning secondarily for water quality. The site is not yet complete, but will receive stormwater runoff from the giant Multnomah County Exposition Center parking lot located nearby.

Site #6. N.E. Airport Way & 116th, Haz-Mat Pond.

This facility was built and is managed by PTD. It is a permanent wet pond designed to capture hazardous material spills in the event of an accident on N.E. Airport Way or from the adjacent shopping center parking lots. A number of gate valves are incorporated into the design to allow hazardous materials to be trapped within the confines of the structure. A concrete maintenance ramp allows equipment to access the bottom of the pond for maintenance. MCVC regularly treats this site for *Culex tarsalis* and *Anopheles punctipennis*. The concrete vaults that house the flood gates provide additional shaded habitat for larval mosquitoes and retain water for most of the year. Vegetation around the perimeter of this site is generally minimal.



Site #7. N.E. Airport Way & 116th, Haz-Mat Pond #2.

This facility was also built by and is managed by PTD. It was designed very similarly to Site #6 described above. However, the access around this pond is limited by dense vegetation growing around the perimeter making mosquito surveillance and control difficult. In spring and summer, blackberry vines can create a nearly impenetrable barrier.



Site #8. N.E. Airport Way & 132nd, Drainage District Extended Detention Basins.

These two basins were designed and built by PTD, but are currently managed by EMCDD. They are two in-line settling basins connected by underground pipes. They receive stormwater runoff from the adjacent roadways, but do not drain completely and hold water year-round. They have the same mosquito problems associated with all of the permanent wet ponds. Access to the site is excellent by means of a gravel road and the ponds are easy to walk around. However, the banks of the ponds are very steep and there is no access for maintenance equipment to enter the ponds to perform maintenance.



Site #9. N.E. Airport Way & 170th, Haz-Mat Pond.

This was another wet pond designed and built by PTD for hazardous material spill recovery as discussed in Sites #6 & #7 above. It is currently managed by EMCDD. This site is considerably larger than the previous sites, but has similar mosquito problems. Vegetation, especially blackberry vines, can create impenetrable barriers around the perimeter of this remote site. MCVC utilizes a small boat to treat this site periodically.

Site #10. N.E. Airport Way & 170th, Mitigation Wetland.

This facility was designed and built by PTD, but is currently managed by EMCDD, and was located near the Columbia River, almost directly across N.E. Airport Way from Site #9 described above. The area is a mitigation zone. A series of five ponds were built for wildlife habitat that receive water from a pump station that taps into an underground aquifer. The ponds are interconnected by underground pipes. Water is present at this site year-round and is regularly treated for mosquitoes that utilize these permanent bodies of water. Beaver are a problem at this site. The photos below illustrate a pond connector pipe grate partially clogged by beaver activity as well as the dozens of fallen trees cut by the beaver. MCVC regularly removes beaver dams and obstructions from this site allowing the ponds to properly drain to their designed levels.



Site #11. Interstate 84 & N.E. 147th Ave, Concrete Detention Basin.

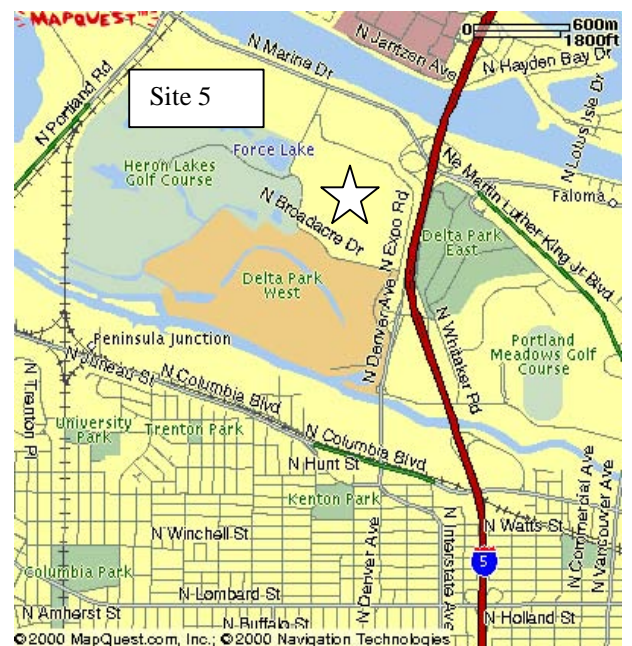
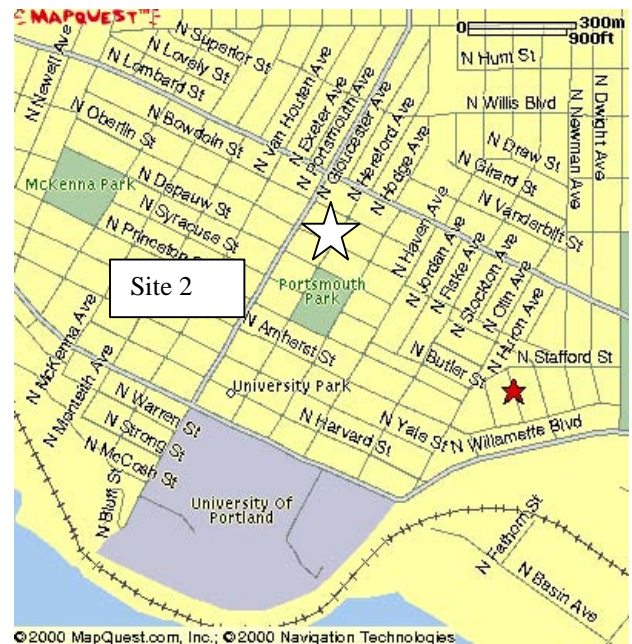
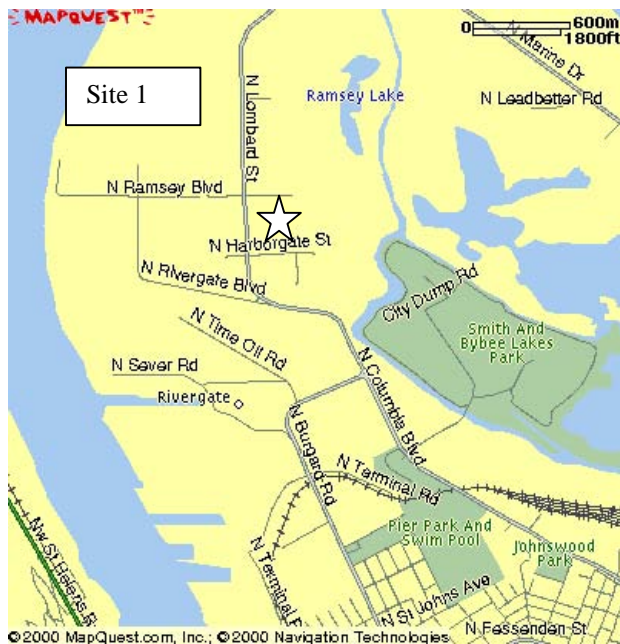
This facility was designed, built, and is maintained by ODOT to receive stormwater runoff from Interstate 84. It holds water all year and is a source of the "permanent water" mosquito species discussed above. This site does not drain completely creating ideal habitat for mosquito larvae. In addition, there are very steep banks with no access road for mosquito control or for maintenance. ODOT informed us that a small tractor had been carefully lowered into this basin using chains for sediment removal. Because of the difficulty encountered, sediment and debris were piled into a corner and left behind (see photo) for eventual removal.

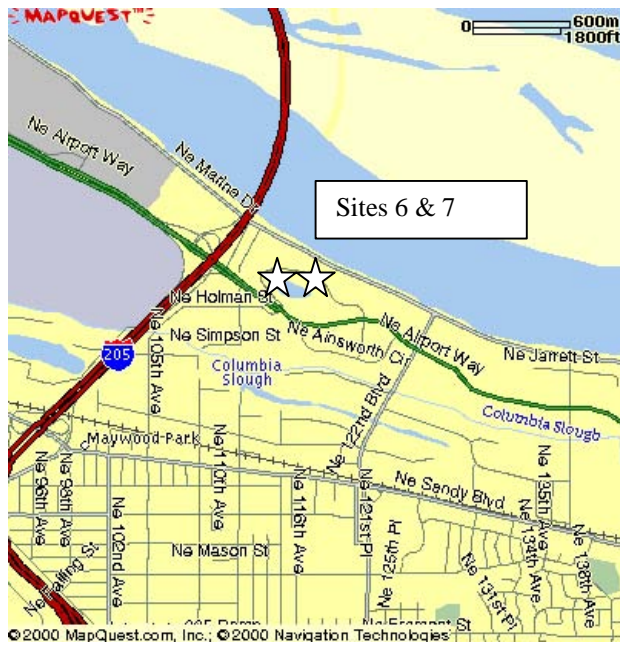


March 7th, County Vector Control / City of Portland Tour Regional Map with BMP Site Locations



March 7th, County Vector Control / City of Portland Tour Site Location Maps





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APPENDIX C:

Summary Report of a Visit to Austin, Texas

Exploring Structural Best Management Practices for Treating Stormwater Surface Runoff outside California

Summary of a Visit to Austin, Texas

Introduction

For the past year, the California Department of Health Services, Vector-Borne Disease Section (VBDS) has been gathering information on vector issues associated with structural Best Management Practices (BMP) for surface water runoff built outside the state of California. The primary purpose of this study was to develop a better understanding of the vector problems and solutions associated with different structural BMPs from vector control agencies. However, it also was intended to provide opinions and attitudes of vector control personnel toward the construction of these BMP structures and an indication of their abundance and distribution. As a direct result of the report based on this study, VBDS was asked to further explore vector issues associated with structural BMPs in specifically chosen cities and states known to have actively addressed surface water runoff through the use of BMPs.

This addendum to the original study is not limited to vector control agencies, but also includes other agencies involved with stormwater and/or local NPDES permits. For consistency, the same questionnaire was used to gather information; however, the study also includes summaries of telephone conversations and other information obtained. To further validate this study, VBDS was asked to travel out-of-state to gain further experience and make visual assessments of BMP structures.

Austin is the only city in the state of Texas to have voluntarily implemented Best Management Practices (BMP) for treating urban surface stormwater runoff. Structural BMPs must be included as part of all new development in the City of Austin. There are only three types of structures that can be built for treating stormwater runoff: sand media filters, wet ponds, and retention / irrigation ponds. Retention / irrigation ponds redistribute water over the surrounding vegetated ground via sprinkler system and are used primarily in new developments that are subject to "no discharge" rules.

Sand filters are the BMP structure of choice and there are thousands, particularly in the newer suburbs. There are two basic types of sand media filters: full-sedimentation and partial-sedimentation. Full-sedimentation structures have a solid separation between the sedimentation chamber and the sand media filter, whereas some water mixing occurs between the two chambers of partial-sedimentation structures. Full-

sedimentation structures are preferred by the City because they are thought to require less maintenance due to their large size. In contrast, partial-sedimentation structures are preferred by commercial / industrial developers because of the less overall space they require for a given runoff area. This is done despite the theory that partial-sedimentation structures will require more frequent maintenance because they are smaller and are more subject to becoming overloaded. The City of Austin, Watershed Protection is ultimately responsible for maintaining most BMP structures once development is complete. However, in the case of commercial / industrial development, the permanent owner of the building is ultimately responsible for the maintenance of the property's BMP structure(s).

Ideally, the City would like to have maintenance performed on their structural BMPs yearly, or at least every three years. However, in reality, many structures have not been maintained for much longer periods, or never. Apparently maintenance funding is not factored into city ordinances for these structures. In addition, it is likely that the actual number of sand filters in existence is unknown.

The City of Austin, Watershed Protection agency apparently has no working relationship with Austin / Travis County Health Department, Rodent and Vector Control. However, they stock all of their constructed wet ponds with *Gambusia* for mosquito control. Despite this, ponds retrofitted into existing neighborhoods are often met with resistance from local residents who fear potential mosquito problems.

Some information on the status of mosquitoes in Texas was gleaned from presentations given at the American Mosquito Control Association conference in Dallas. There are a variety of mosquito-borne diseases found in the state of Texas including St. Louis Encephalitis (SLE), LaCrosse Encephalitis (occasionally), Eastern Equine Encephalitis, Malaria (a few indigenous cases), and Dengue, which is the most common. There are several mosquito species of special concern. *Culex quinquefasciatus* is a competent vector of encephalitis, *Aedes albopictus*, also known as the Asian Tiger, is the main vector of dengue, and *Aedes vexans* and *Psorophora spp.* can create public nuisances. There is concern with SLE because there have been outbreaks as recent as 1995. *Aedes albopictus* breeds primarily in small containers and old tires. Private residences contribute to most of these mosquitoes, whereas *Culex quinquefasciatus*

breeds in larger bodies of water, especially those that are highly polluted such as inside storm sewers.

On short notice, Marco Metzger, a public health biologist with VBDS who was attending the AMCA annual conference in Dallas, organized a meeting for February 21, 2001 with two people in Austin: Matt Hollon (Glenrose Engineering) and Mike Barrett (University of Texas). The purpose of this meeting was to discuss and visit different structural BMPs, with particular interest in understanding design and maintenance factors that could influence vector production. We met at the Central Market at 11:30 AM. The approximately 3-hour meeting included visits to 9 structures within the city. The following list provides a short summary and photos of each site. A regional map with marked locations follows the list.

Site #1. Central Park, Wet Pond.

This series of ponds was designed by the City of Austin and is probably maintained through a contract with the neighboring shopping center. It receives urban water runoff from the shopping center parking lot, rooftops, and surrounding city streets. The three inlet pipes (2nd picture) suggest that this structure is capable of receiving large volumes of water. The structure was designed for water quality purposes, but it was also built for aesthetics and even has a fountain. It was noted that there were thick stands of living and dead cattail plants around the perimeter that appeared conducive to mosquito production (3rd picture).



Site #2. Far West, Flood Control / Water Quality Basin

This site was originally excavated for flood control purposes. It was later expanded (retrofitted) by the City of Austin to comply with water quality standards for incoming flow. To function as a water quality structure, the first basin became a settling chamber of sorts and a second basin was built (in the background of the first picture) to serve as a permanent water treatment wet pond. Overflow water then ultimately discharges into an adjacent creek. To allow for easy monitoring, several inflows along the roadway were modified to flow through a single narrow channel (2nd and 3rd pictures). It was noted that this structure was in disrepair and in severe need of maintenance and provided excellent habitat for mosquitoes. The inflow area leading from an inflow pipe to the main concrete inflow channel was (2nd picture) was flooded with approximately 8-12 inches of water, which based on plant and animal life, looked as if it had been there for months. The concrete channel that directed water from the inflow area into the first basin was flooded and had several large trees growing through the concrete (3rd picture).





Site #3. Quarry Lake Area, Sand Media Filter #1

This structure receives water runoff from the adjacent office building, roadway, and parking lot. It is a full-sedimentation structure as noted by the two separate chambers. It was built by the developer, but the building owner(s) is ultimately responsible for its function and maintenance. It was noted that the inlet channel was partially clogged with sediment accumulation and it appeared that water remained stagnant in the "dead-end" section, possibly due to a faulty grade.

Note: All sand filters visited were soil-lined.



Site #4. Quarry Lake Area, Sand Media Filter #2

This site was built near Site #3, on the other side of the adjacent office building. As noted previously for all commercial / industrial buildings, it was built by the developer, but the building owner(s) is ultimately responsible for its function and maintenance. It receives runoff from the building and from the parking lot. It is a partial-sedimentation unit, as noted by the rock wall held together by galvanized mesh (chicken wire), which allows some flow-through of water from the sedimentation side to the sand media side. No water was noted at this site.



Site #5. Quarry Lake Area, Sand Media Filter #3

The following three sites, Sites #5, 6, and 7, are all similar in function, but differ slightly in shape because their shapes conform to the parking lots. These sites were associated with a group of office buildings just down the street from Sites #3 and #4. They were all on different corners of the parking lot, literally 1-2 minute walking distance or less. They are all partial-sedimentation units, again as noted by the rock wall separating the two chambers. No significant areas of standing water were noted, but the deep structures with little or no barrier to falling (or driving) into them was alarming.



Site #6. Quarry Lake Area, Sand Media Filter #4

Same as above, but the outflow channel into which all the units discharge treated water can be seen in the foreground.



Site #7. Quarry Lake Area, Sand Media Filter #5



Site #8. Quarry Lake Area, Giant Sand Media Filter

This was an enormous full-sedimentation sand filter located behind Seton NW Hospital in the Quarry Lake area. It was built by the Texas Department of Transportation along with the City of Austin; however, the City currently maintains it. This unit receives runoff from approximately 70 acres of nearby roadways and commercial runoff. The inlet was retrofitted into an existing flood channel to redirect water flow into the structure. The structure was currently undergoing maintenance due to clogging of the sand media. Because of this, areas in this structure that might hold standing water could not be assessed. However, the inlet area in the flood channel did have large areas of standing water that appeared to be there as a result of a faulty grade and sediment accumulation.



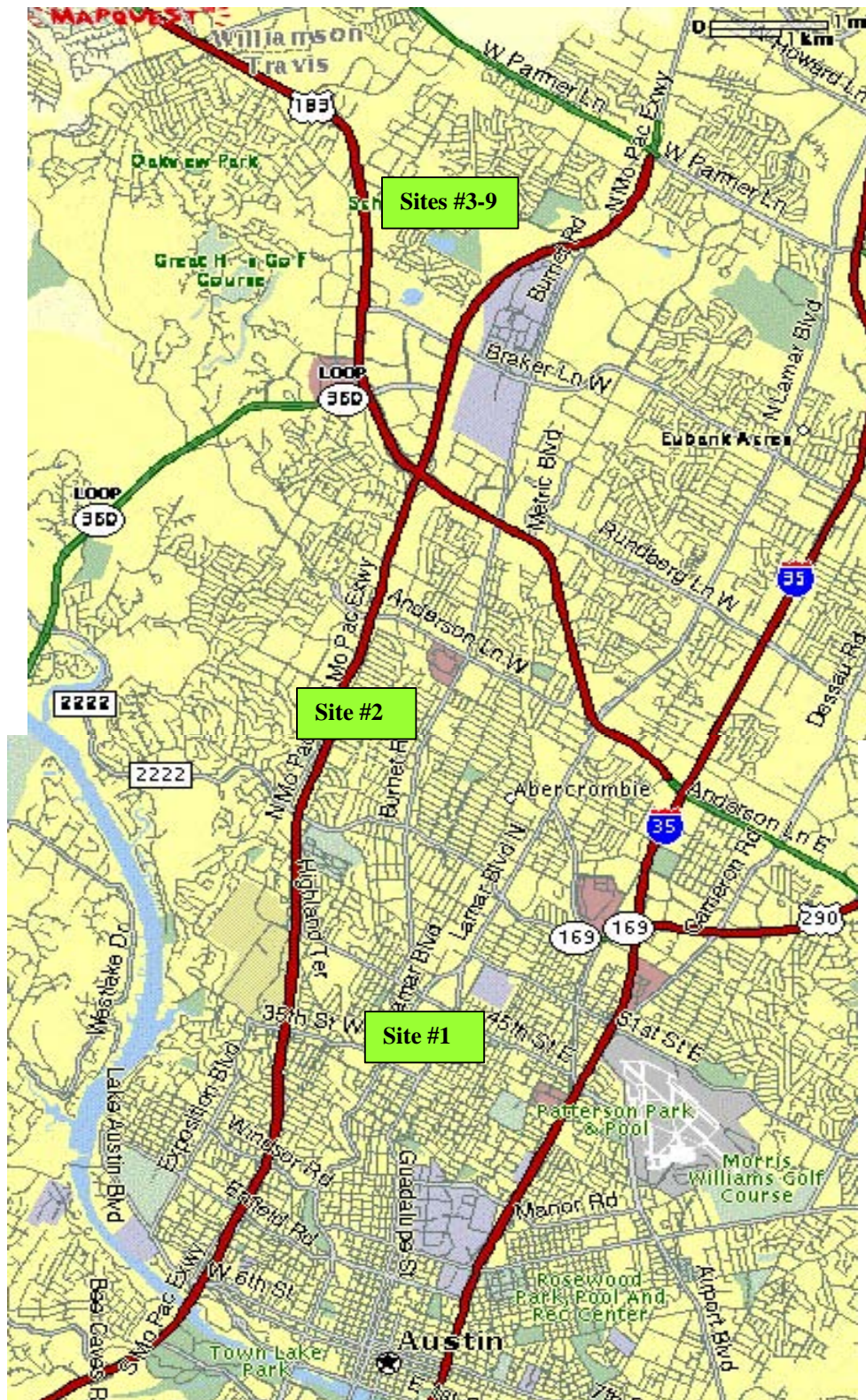


Site #9. Quarry Lake Area, Small Sand Media Filter

This was the final site visited. It was a very small full-sedimentation sand filter associated with the adjacent parking lot of a small shopping center. It was approximately a mile from the other sand filters visited. No standing water was noted.



Austin, Texas Regional Map with BMP Site Locations



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APPENDIX D:

Maryland Department of Agriculture

"A preliminary survey for mosquito breeding in stormwater retention ponds in three Maryland counties"

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Maryland Department of Agriculture

"A preliminary survey for mosquito breeding in stormwater retention ponds in three Maryland counties"

A PRELIMINARY SURVEY FOR MOSQUITO BREEDING
IN STORMWATER RETENTION PONDS
IN THREE MARYLAND COUNTIES

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Introduction

The Washington DC/Baltimore Region has experienced rapid increases in land development in recent years. Several areas in Maryland counties are being developed at an ever increasing rate. The population growth over the last 10 years in Montgomery and Howard counties was 18% and 45% respectively, with a 10% and 18% growth in the last 3 years. With the increased demand for housing, land is being developed wherever possible. Development creates impervious surface areas which increase runoff and erosion. Various stormwater management structures have been developed and used successfully in the past to reduce flooding and to hold water after rains for slow release into discharge streams. The boom in real estate development in this area has led to a large increase in the number of stormwater structures in the last 5 years. Each structure, due to its water-holding capacity, has the potential to support mosquito populations.

Along with the increase in the number of stormwater structures, there has been a change in attitude towards function of these structures. The amount of development within the Chesapeake Bay watershed is believed to have contributed to the Bay's state of decline due to increased sedimentation, turbidity, nutrient overloading and chemical pollution (Adams et al, 1984). In 1983, as a result of this decline; water quality concerns were incorporated into stormwater management practices and required by Maryland State Law 8-11A-03 (Harrill, 1985). In accordance with this law, stormwater management practices must now be prioritized, with higher priority given to methods which increase the entrapment of pollutants.

The types of stormwater management used in Maryland, in order of effectiveness for both flood and pollutant control are: infiltration, vegetated swales, retention ponds, and detention basins. Infiltration is a system which allows some or all of the excess runoff from developments to infiltrate into the ground (Harrill, 1985). This system is rarely used in Maryland because of geological constraints. Vegetated swales, when constructed with check dams, provide filtering through vegetation and infiltration into the soil. This system has many of the same problems as infiltration and is rarely used.

Retention ponds, or wet ponds, maintain a certain water level at all times. Wet ponds seem to be superior to dry detention basins at both physical entrapment and biological incorporation of pollutants (Adams et al, 1984). The use of a riser in these ponds contributes to better pollutant removal by allowing only the upper levels of cleaner water to run out (Randall, 1984). Aquatic plants such as species of pondweed, smartweed, cattail and sedge often become established in wet ponds (Adams et al, 1984). The Maryland Water Resources Administration, the U.S. Fish and Wildlife Service (USFWS) and Maryland's Department of Natural Resources (DNR) are all in the process of developing criteria and guidelines for designing shallow water wetland areas which would encourage the establishment of aquatic vegetation for stormwater management and water quality improvement (Harrill, 1985; Adams et al, 1984).

Detention basins, or dry ponds, are designed to hold water temporarily and release it slowly to the discharge stream. These ponds often have low areas along the sides or are rutted by maintenance equipment, allowing pockets of water to remain long after rains. Dry ponds with streams often have wet bottoms and are not properly maintained, permitting the growth of wetland plants (Adams et al, 1984).

Mosquito problems in stormwater ponds result from poor design or construction of the ponds, or from the growth of aquatic or emergent vegetation capable of supporting or sheltering mosquito immatures. Very little hard data is available on the number or types of ponds which support mosquito

populations. This study was designed to provide data for Prince Georges, Montgomery and Howard county ponds in Maryland.

Materials and Methods

From January to April 1988 surveys were made of stormwater ponds in housing and industrial developments in Prince Georges, Montgomery and Howard counties. Since the state or county agencies contacted prior to this study had no comprehensive list of stormwater ponds, a method was devised to locate ponds. Older street maps of each county (1982 for Montgomery, 1984 for Prince Georges and Howard) were compared with new maps and all new subdivisions or industrial parks were marked for survey.

Each marked area was surveyed and all stormwater ponds found were drawn onto a master map and classified to type. A number of wet and dry ponds in each county were chosen randomly to be checked for mosquito populations throughout the season. A log card was made up for each study pond containing the following information: site number, location, date and water level at initial survey, date and water level at each breeding check, positive/negative for mosquitoes, number of larvae/dip, and species present.

A standard hand dipper was used for all breeding checks. Wet ponds were sampled along edges at regular intervals. Dry ponds were checked for any areas of standing water. If standing water was found, it was sampled for larvae. Any larvae or pupae collected were brought back to the lab for identification. No surveys for Coquilleltidia larvae were attempted in vegetated wet ponds due to the difficulty involved in such surveys.

Results

During the initial survey, over 300 stormwater ponds were found. This number is believed to be well short of the actual number of ponds in each county because this survey focused only on recently developed areas. Of the 300 ponds, 139 were monitored for mosquito populations during the 1988 season: 24 in Prince Georges County, 64 in Montgomery County, and 51 in Howard County.

Dry Ponds - Eighty three dry ponds were checked. Fifty eight (70%) of these ponds held water at some time during the season in various ruts, depressions, ditches or low areas at outflow pipes. Thirty eight (46%) of the dry ponds checked contained mosquito larvae at some point during the season. Ten (18%) maintained mosquito populations throughout the season. The 7 species found in dry detention ponds were: Anopheles punctipennis, An. crucians/bradleyi, Aedes vexans, Culex pipiens, Cx. restuans, Cx. salinarius, and Cx. erraticus.

Wet Ponds - Fifty six wet ponds were checked. Mosquitoes were found in 28 (50%) of these ponds. Of the 28 breeding wet ponds, 21 (75%) had some form of aquatic or emergent vegetation, most often cattails. Ten (18%) of the 56 ponds checked, bred consistently throughout the season. The 6 species found in wet ponds were: An. quadrimaculatus, An. punctipennis, Ae. vexans, Psorophora howardii, Cx. pipiens, and Cx. territans.

Discussion

In a study done in 1983 in Columbia, Maryland on urban wetlands for stormwater control and wildlife enhancement, Adams reported that though 6 species of mosquitoes were recorded in their study ponds, Cx. territans was the most abundant and it did not attack man. Furthermore, Adams found that all ponds containing mosquitoes also had either predaceous aquatic insects or sunfish, and

speculated that these would act as natural control agents to keep the mosquito populations in check. These observations are not consistent with the findings of this study. The most abundant species of mosquito found in wet ponds were An. punctipennis and Cx. pipiens, both of which regularly attack man. Cx. territans was occasionally found in small numbers. Many wet ponds had no fish and few predatory insects present.

In Morris County, New Jersey in 1980, Schimmenti (Schimmenti, 1980) found construction or design problems with every retention and detention basin in the county, but relatively few were found to breed mosquitoes. He stated that pond design and construction was often done seemingly without knowledge of or concern for the ramifications resulting from stagnant water (Schimmenti, 1980).

Two sets of guidelines for stormwater ponds, one by Schimmenti, a mosquito control engineer, and one by the National Institute for Urban Wildlife, point to the difficulties in planning ponds with two different aims in mind.

Schimmenti's guidelines would greatly reduce mosquito problems in stormwater ponds. They are as follows:

Detention Basins

- Dry ponds should have grass or concrete lined low-flow channels from inlets to the outlet structure and a concrete apron at the base of each inlet to prevent water pockets at the pipes.
- The floor should be uniformly sloped (1.5-2% minimum) to the low-flow channels or to the outlet structures.
- The grass floor should be firm enough to support maintenance equipment.
- No standing water should be present after 5 days within the basin or in exit channels.

Retention Basins

- Wet ponds should have water quality sufficient to support surface-feeding fish.
- Grass should be mowed routinely to the pond edge.
- Water depth of 4 feet or more should be maintained to prevent emergent vegetation.
- Pond edges below the water surface should be fairly steep, uniform, and free of vegetation (Schimmenti, 1980).

The National Institute for Urban Wildlife's guidelines, set out in 1982 following DNR and USFWS recommendations for establishment of wetlands for stormwater management, could cause serious mosquito problems by creating prime mosquito habitat in new areas. Their guidelines follow:

- Wet ponds should have gently sloping sides to encourage the establishment of marsh vegetation.
- Water depth should be under 2 feet for 25-50% of the pond's surface area.
- A 50:50 ratio of emergent vegetation to open water should be maintained (Adams, 1984).

This abundance of emergent vegetation could provide habitat for Coquilleltidia populations as well as shelter for various other species of mosquitoes.

Conclusions

The proximity of stormwater ponds to human habitation is of concern to mosquito control personnel. In many cases in Maryland, stormwater ponds are constructed within 50-100 feet of new homes in a subdivision. Cx. pipiens and Cx. restuans were found breeding in ponds near homes. Both have potential as vectors of St. Louis encephalitis, Cx. restuans for amplification and maintenance of the virus in avian reservoirs (Francy et al, 1981), and Cx. pipiens as the principal

vector of the virus to man (Wood et al, 1979).

The percentage of breeding ponds in this study was much higher than those obtained informally from mosquito control agencies in other areas on the East Coast (Etherson, City of Gainesville, Parsons, Sarasota County, FL, 1989, personal communications). Breeding potential in stormwater ponds should be monitored in all fast-developing areas.

Stormwater ponds are still being constructed at a tremendous rate. Keeping records of new ponds as well as monitoring known ponds requires a good deal of time. An increase in funding will be required for the necessary surveillance and control work in the ponds.

The water-holding nature of stormwater ponds and their proximity to human populations make them important potential sources for increased nuisance mosquito problems. There is potential for Coquillettidia problems in wet ponds and disease problems in areas where there were no previous problems. Since these ponds are required in all new developments, workable solutions must be found. Stocking of wet ponds with Gambusia species or other surface-feeding fish is one possible answer. Eight study ponds in Maryland were stocked with Gambusia in August and September 1988 and were monitored during the 1989 season. One approach to the problem is for mosquito control personnel to become involved in the planning and design process for stormwater ponds. Design features could be incorporated which would eliminate or reduce the potential for mosquito breeding while maintaining water quality standards. Chemical control in stormwater ponds may always be necessary if compromises cannot be reached on design of the ponds.

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APPENDIX E:

**New Jersey Department of Environmental
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***"Best Management Practices for Mosquito Control and
Freshwater Wetlands Management"***

**BEST MANAGEMENT PRACTICES
FOR MOSQUITO CONTROL
AND
FRESHWATER WETLANDS MANAGEMENT**



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BEST MANAGEMENT PRACTICES FOR MOSQUITO CONTROL

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NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
MANUAL ON
BEST MANAGEMENT PRACTICES FOR MOSQUITO CONTROL
AND FRESHWATER WETLANDS MANAGEMENT

A Manual of Freshwater Wetland Management Practices
for Mosquito Control in New Jersey

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Representatives from the various Federal and State agencies provided valuable review and comment during the development of these wetland management practices. This contribution of constructive criticism and recommendations by concerned natural resource professionals has served to assure that these Best Management Practices are consistent with the intent of the New Jersey Freshwater Wetlands Protection Act of 1987.

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Office of Mosquito Control Coordination
Green Acres program
Land use Regulation
Division of Fish, Game and Wildlife
Division of Parks and Forestry

U.S. Fish and Wildlife Service
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency
U.S.D.A. Natural Resources Conservation Service

TABLE OF CONTENTS

	<u>PAGE</u>
Acknowledgments.	i
Introduction	1
The New Jersey Freshwater Wetlands Protection Act of 1987	3
Endangered and Threatened Species of New Jersey	4
Administrative Procedures for Issuance of a General Permit #15 for Mosquito Control Wetland Management	6
Guidelines for Preparation of Wetland Mosquito Control Management Plan	8
Delineation of Freshwater Wetlands	8
Wetland Hydrology	
Wetland (Hydric) Soils	
Wetland Vegetation	
Soil Stabilization in Managed Wetland Areas	12
Vegetation Disturbance	13
Excavation Equipment	13
Basic Principal of Wetland Management for Mosquito Control	14
Basic Practices for Freshwater Wetland Mosquito Control Management	15
Shallow Channel Restoration	
The Drainage Swale	
The Low Level Management Sill	
Best Management Practices for Mosquito Control in Stream Corridor Wetlands	17
Best Management Practices for Mosquito Control in Palustrine Freshwater Wetlands	20
Best Management Practices for Mosquito Control in Isolated Freshwater Wetlands	21
Best Management Practices for Mosquito Control in Construction Disturbed Freshwater Wetlands	22

	<u>PAGE</u>
Best Management Practices for Mosquito Control in Stormwater Facilities	27
Mitigation Wetlands	31
Appendices	33

Appendix 1 - Definitions

Appendix 2 - New Jersey Plants Under Review
for Federal Listing as Endangered
Species

Appendix 3 - Endangered/Threatened Fauna of
New Jersey

Appendix 4 - Freshwater Wetland plant Types
Occurring in New Jersey

Appendix 5 - Grasses for Conservation in the
Northeast

Appendix 6 - Freshwater Management Ponds

Appendix 7 - Department of Environmental Protection
Land-Use Regulation Program Application
Form (LURP #1)

INTRODUCTION

Although wetland values have been recognized for many years, efforts to preserve freshwater wetlands through regulation are relatively recent. Public agencies such as the US Environmental Protection Agency are actively engaged in wetland research of a basic and applied nature. Various organizations are also actively engaged in the training of wetland managers through numerous publications and seminars.

Both the US Environmental Protection Agency and the New Jersey Department of Environmental Protection have identified urban quality stormwater runoff as a major pollutant which often contains high concentrations of toxic materials. Large volumes of this pollutant are regularly flushed from developed areas into wetlands throughout much of the State. Sedimentation from both agricultural and construction activities has also been a major source of degradation of freshwater wetlands, particularly those situated within stream corridors.

The New Jersey Department of Environmental Protection, has concluded that stormwater runoff is a significant contributor to degradation of ground and surface waters and to the violation of water quality standards. Pollution in stormwater runoff from urban and urbanizing areas is a major environmental problem. It is reasonable to conclude that repeated recharge of freshwater wetlands by urban type stormwater runoff will have a significant and cumulative adverse impact upon that wetland environment. These destructive impacts include the loss of natural mosquito predators, and fluctuating wetland water levels. These conditions often create mosquito producing habitat which may be in close proximity to residential areas. The preservation of healthy freshwater wetlands, unpolluted by excessive urban stormwater runoff and/or sedimentation is, therefore, of vital concern to mosquito control agencies throughout the State.

Altered Wetland Hydrology

As upland areas adjacent to freshwater wetlands are developed, the natural hydrology of the wetlands is usually disturbed. First, existing ground infiltration is reduced by the construction of impermeable surfaces such as sidewalks, parking lots and streets. Secondly the radically increased surface runoff is released into a stormwater facility, or nearby wetland areas and streams. Consequently, there are predictable and pronounced impacts upon the wetland's hydrologic regimen. These impacts include:

1. sub-surface wetland recharge diminishes
2. the wetlands become dependent upon surface recharge sources and precipitation
3. water enters the wetlands from a few concentrated storm water discharge points
4. stormwater enters wetlands in surges often at increased rates and volume
5. the quality of the stormwater runoff is reduced, delivering toxic contaminants to the wetland.

Any one of these hydrological changes, in itself, is capable of degrading or altering the freshwater wetland environment and creating a mosquito producing habitat.

Preventative wetland protection realized through regulation of stormwater management design is, therefore, the most effective mosquito control procedure in urbanizing areas. Where an existing wetland system is already experiencing the degrading effects of urban runoff, management of the wetland hydrological regimen will provide an effective and environmentally responsible method of mosquito control, without the use of pesticides.

The New Jersey Freshwater Wetlands Protection Act of 1987 has significantly reduced the extent of more physical encroachment and gross alteration in the State's wetlands. In urbanizing areas, however, the adverse impacts of stormwater runoff continues to be a source of degradation and mosquito habitat production in both on-site and impacted off-site wetlands. Consequently, the demand from the general public for mosquito control water management in these impacted wetlands has increased. **NJSA 26:9-1-31** provides the enabling legislation for mosquito control agencies in New Jersey. Operating under the mandates of Title 26, a county mosquito control agency has broad authority to undertake remedial action "which in its opinion, may be necessary for the elimination of mosquito breeding areas, or which will tend to exterminate mosquitoes within the county (NJSA 26:9-21)".

Ongoing research will hopefully provide continuing insights into wetland functions which will assist in the development of a better understanding of optimum wetland management technology. In the interim, mosquito control agencies are mandated to address wetland mosquito problems, utilizing presently available data, and the best management practices available.

Whether degraded by urban stormwater runoff or not, freshwater wetland mosquito habitat, which impacts residential areas, requires attention. Pesticide usage will remain the dominant mosquito control option during the active mosquito season, between late March and October. However, encroaching development is making pesticide applications increasingly more difficult in these wetlands. Land development trends throughout the state now dictate that effective mosquito control programs include sensitive physical management of freshwater wetland mosquito habitat.

**THE NEW JERSEY FRESHWATER WETLANDS PROTECTION ACT
OF 1987 (N.J.A.C. 13:9b-1 et seq.)**

The intent of the Freshwater Wetlands Protection Act is to preserve the purity and integrity of the freshwater wetlands of New Jersey from random, unnecessary or undesirable disturbance. The ACT does not prohibit all wetland alteration, but does clearly establish three broad criteria by which any proposed wetland disturbance is to be evaluated. Any disturbance will be:

1. planned, rather than random;
2. necessary; and
3. desirable.

Mosquito control management activities in freshwater wetlands must satisfy these criteria. Proper planning, which includes documentation of both the necessity and desirability of wetland management for mosquito control, is a key factor of the Best Management Practices.

The ACT mandates that freshwater wetland management for mosquito control be authorized under a general permit classification on a State-wide or regional basis (Section 23.c). A General Permit #15 has been created to expeditiously allow certain wetland activities for the purpose of controlling mosquito production in the State's freshwater wetlands.

ENDANGERED AND THREATENED SPECIES OF NEW JERSEY

The Freshwater Wetlands Protection Act classifies wetlands into 3 categories:

1. exceptional resource value
2. intermediate resource value
3. ordinary resource value

One criterion of an exceptional resource value wetland shall be that endangered or threatened plant species are present, or it is a documented habitat (determined by the Department to be suitable for breeding, resting or feeding) for threatened or endangered animal species. The other criterion is that it discharges into FW-1 waters and FW-2 trout production waters and their tributaries.

Often, wetland wildlife or plants attain their endangered or threatened status as a direct result of human encroachment and physical stress upon their habitat. Continued industrial and residential development throughout the State will likely place additional stress upon these plants and animals as it also contributes to the formation of mosquito habitat.

County mosquito control agencies should be aware of, and concerned about, any endangered or threatened species within their counties and the potential impact mosquito control activities may have upon them.

A list of the New Jersey flora and fauna presently considered threatened or endangered is provided in Appendix 2 and 3.

Additional information on New Jersey's endangered and/or threatened species may be obtained from the following New Jersey State agencies:

New Jersey Department of Environmental Protection
Division of Fish, Game & Wildlife
Office of Endangered and Threatened Species
CN 400
Trenton, NJ 08625
(609) 292-9400

New Jersey Department of Environmental Protection
Division of Parks and Forestry
Office of Natural Lands Management
CN 404
Trenton, NJ 08625
(609) 984-1339

New Jersey Department of Environmental Protection
Land Use Regulation
CN 400
Trenton, NJ 08625
(609) 984-3444

ADMINISTRATIVE PROCEDURE FOR ISSUANCE OF A GENERAL
PERMIT #15 FOR MOSQUITO CONTROL WETLAND MANAGEMENT

A county mosquito control agency shall submit a brief description of the wetland area proposed for management, with supporting mosquito control documentation, to the Administrator of the Office of Mosquito Control Coordination (OMCC), within the Department of Environmental Protection. Following preliminary review and approval by the Administrator, the county agency will proceed with submission of a completed Land Use Regulation Program Application Form (LURP #1), (Appendix 7) to the Department of Environmental Protection, Land Use Regulation program, CN 400, Trenton, NJ 08625, for final review and approval.

Each general permit application should contain the following:

Completed LURP-1 Application Form

Permit Application Review Fee (payable to Treasurer, State of New Jersey.)

Certified Mail Return Receipts

Verification of publication in a newspaper of local and one of regional circulation

Location Map (a copy or portion of a U.S.G.S. Topographic Quadrangle Map with the project site outlined and state plane coordinates.

Original Color Photographs of the portion of the property for which authorization is being applied for.

A Statement of Compliance to determine whether conditions of the general permit (listed in N.J.A.C. 7:7A-9.2) for which you are applying will be satisfied per N.J.A.C. 7:7A-9.5(a)2.

Site Plan (3 folded copies) detailing existing structures, proposed structures or activities, and a delineation of the wetlands boundary for the area of proposed disturbance.

A signed statement certifying that the proposed activity will not result in any direct or indirect adverse impacts to Swamp Pink (*Helonias bullata*) or its documented habitat in any of the municipalities listed in N.J.A.C. 7:7A-9.5(a)2iii(1).

A narrative description of the mosquito problem in the area and the best management practices proposed to correct the problem. It is recognized that mosquito control records may be sparse in areas of new mosquito habitat. In general, however, an effort should be made to provide the most complete records in order to expedite preliminary project review.

GUIDELINES FOR PREPARATION OF A FRESHWATER WETLAND MOSQUITO CONTROL MANAGEMENT PLAN

A freshwater wetland management application for mosquito control should include not only a general description of the wetland, but enough site specific information to:

1. describe the mosquito producing conditions;
2. determine the appropriate best management practices to be employed; and,
3. facilitate an accurate and timely review of the proposed wetland activity by the N.J. Department of Environmental Protection.

The purpose of the following section is to provide county mosquito control agencies with basic wetland information and guidelines to assist them in establishing the boundary and character of the freshwater wetlands as part of the mosquito control management planning process.

DELINEATION OF FRESHWATER WETLANDS

The New Jersey Freshwater Wetlands Protection Act requires that freshwater wetlands be identified by 3 parameters: wetland hydrology, hydric soil, and wetland vegetation.

Wetland Hydrology

Hydrology may be defined as a science dealing with the properties, distribution, and circulation of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere. For the purpose of mosquito control wetland management planning, three wetland hydrologic features should be identified, and recorded. This site data will assist in determining which mosquito control management practice will be most appropriate and effective for a particular site. These features are:

1. the area and depth of surface water or depth to groundwater within saturated wetland soils,
2. the locations of water entering the wetland, and
3. the routes (if any) by which water is discharged from the wetland.

Field inspections are usually required to provide specific details of these site features. However, in many areas much valuable site information is readily available on existing maps. Time spent gathering and reviewing existing area mapping is a solid investment in the development of a sensitive and effective wetland management plan. Information relative to area roadways, drainage features, and residential development, is basic to an understanding of the dynamics which generate and influence wetlands in their urbanizing context. Sources of adverse wetland impacts, which create and maintain mosquito habitat, can often be identified through existing area map review.

Several map information sources are readily available. These include:

1. USGS Quadrangle maps, which contain topographic data, drainage features, and area roadways.
2. Aerial photographs, which provides an overview of all land and drainage features. However, some experience in aerial photo interpretation may be necessary to utilize this resource.
3. Municipal and county topographical mapping is a valuable source of existing land and drainage features, usually providing land surface contours at 1-2 ft. intervals.
4. National Wetlands Inventory Mapping (US Fish and Wildlife Service) is a primary source of approximate wetland delineation and freshwater wetland typing.
5. New Jersey Department of Environmental Protection Wetlands Maps are a source of accurate freshwater wetland delineation.
6. USDA soil conservation soil survey mapping and explanatory reports provide detailed information relative to the locations and types of wetland soils. Soil survey reports and mapping are usually available from the local US Natural Resources Conservation Service (USNRCS) district.

The presence of surface water is not in itself a reliable indicator of the presence of freshwater wetland. For the purpose of mosquito control management within a confirmed wetland, however, measurement of the observed area of surface water mosquito habitat should be one of the initial steps toward the development of a management plan. The area of surface water should, therefore, be determined and sketched onto a management plan drawing. Additionally, all sources of flow into the wetland, as well as discharge

routes, should be added to the plan drawing.

Wetland (Hydric) Soils

Hydric soils develop naturally in wet depressions, on floodplains, on seepage slopes, and along the margins of inland waters. Hydric soil has been defined by the USNRCS' s soil that is either saturated at, or near the soil surface with water that is lacking free oxygen for significant periods during the growing season, or flooded frequently, for long periods, during the growing season. Hydric soils are separated into two major categories on the basis of soil composition. These include:

1. Organic Hydric Soils (Histosols) - Soils which originate from a build up of organic matter, subjected to long periods of flooding, or saturation. These saturated soil conditions impede aerobic decomposition of organic materials such as leaves, stems and roots, and encourage their accumulation as peat or muck, over time. Organic soils are consequently dark in color, poorly drained, and contain partially composed vegetative matter.
2. Mineral Hydric Soils - Soils which are predominantly gray in color with variable "mottling" of bright colors. A typical mineral hydric soil core is composed of a few inches of organic material at the surface underlain by gray, yellow or orange, sands, progressing to sandy clay, and finally clay. The characteristic color mottling usually occurs as an orange or rust "speckling" within the clay or sandy clay layer.

Although surface water, or wetland vegetation can provide observable evidence of a hydric soil condition, accurate soil boundary delineation requires some soil investigation. As previously noted, published soil surveys for each county in the State are available from the USNRCS. In these detailed soil reports, all soils are classified, assigned a name, described and their boundaries mapped. Those soils which tend to be poorly drained are identified. However, soil borings are needed to obtain site specific data such as the hydric soil boundary, its depth, character and depth to ground water.

The hydric soil boundary can be determined by taking hand auger soil borings near the edge of the observed wetland (i.e. wetland vegetation, surface water) and progressively at 5 or 10 foot intervals toward the upland. When a soil boring first indicates only upland soil characteristics, establish the hydric soil boundary midway between that boring and the one preceding it.

The approximated hydric soil boundary is a useful element of a wetland management plan. More important however, are the depth of the hydric soil zone and, if the FWWL is not inundated, depth to groundwater or saturation. The hand auger boring can also provide this data with reasonable accuracy if auger soil samples are observed carefully and measured as they are taken. Ground water observation borings should be taken several hours prior to recording in order to obtain accurate soil saturation levels.

Wetland Vegetation

Wetland vegetation provides the most reliable observed evidence of freshwater wetland conditions. Wetland vegetation is dependent upon seasonal or permanent flooding or sufficiently saturated soils to give it a competitive advantage over upland plant species. Consequently, the wetland boundary is located at the outer limit of wetland vegetation growth. Unfortunately, however, many wetlands do not have abrupt vegetational boundaries, but rather, a transitional area of variable width wherein wetland and upland vegetation intermix. Accurate delineation of the freshwater wetland vegetation boundary requires identification of the existing wetland plants, determination of species density, and establishing the point at which these wetland species are no longer dominant. The mosquito control manager should be familiar with the common New Jersey hydrophytes and their associated plant communities in order to approximate freshwater wetland boundaries.

As part of the National Wetlands Inventory Program, the U.S. Fish and Wildlife Service has compiled a list of nearly 1,000 wetland plants found in the northeast region of the country. This list categorizes plants by their frequency of occurrence in wetlands. Those plants that require saturated soil or standing water and are always found in wetlands are referred to as "obligate" plants (obl.). Plants that can tolerate wet, or dry conditions, are termed "facultative" plants. Facultative plants are divided into three sub-groups:

1. facultative wetland species, (facw) usually found in wetlands (66-99% of the time),
2. facultative species (fac) found in either wetland or upland situations (found in wetlands 33-66% of the time), and
3. facultative upland species (facu), generally found in uplands, but occasionally found in wetlands.

Examples of these wetland associated plant types occurring in New Jersey can be found in Appendix 4.

The wetland boundary is established at the point where wetland indicator plant species no longer have a competitive advantage over upland species. Wetland and upland plants will mix together at this transition zone. When the intermixing of vegetations becomes an even gradient, the boundary is defined. The boundary line, therefore, is drawn at the mid-point of that zone.

In situations where predominantly facultative plant species are found, the ecological association of that community must be examined to determine if the area is a wetland.

SOIL STABILIZATION IN MANAGED WETLAND AREAS

Minimum soil disturbance in freshwater wetlands should be a major objective of mosquito control wetland management practices. However, some disturbance will be inevitable, especially in stream corridor management where channel restoration is undertaken.

Restoration of severely impacted channels in urban or agricultural areas may require both sediment removal, and "resculpting" of natural channel meanders. Both procedures generate considerable spoil volume. Where excavated materials cannot be feasibly removed from the floodplain, they should be regraded to a depth of no greater than 4 in. Since a considerable area may be disturbed by the regrading process, stabilization of these areas is crucial, especially in a stream corridors subject to the scouring effects of periodic flooding.

Usually, indigenous floodplain vegetative species will revegetate the disturbed areas. However, natural revegetation may require considerable time. It is good practice, therefore, to supplement the natural revegetation process with the establishment of hardy, soil binding, species of grass capable of thriving in saturated soils. Wetland tolerant grasses serve two purposes:

1. they provide soil binding root/rhizome systems, and
2. they provide food and cover for wildlife.

Several species of grass have been designated by the USNRCS as being particularly effective wetland soil binders and good wildlife food and cover. A list of the grasses recommended by the USNRCS for soil conservation in the northeast US is provided in Appendix 5. A mosquito control agency may find it necessary to experiment with varying mixtures of these and other grasses, in order to find the

best blend for site specific conditions.

The following blend, developed by the Rutgers University Turf Management Department, has proven very successful for stabilizing fresh cut stream banks and graded spoil, and provides excellent wildlife cover.

- 60% Perennial Rye Grass
- 8% Kentucky Blue Grass
- 8% Penn Red Fescue
- 4% Red Fescue (creeping)
- 20% Reed Canary Grass

The proper scheduling of wetland management projects is also a very important soil stabilization factor. Excavation, and regrading of the excavated spoil, should be completed early enough in the growing season to allow adequate time for germination and establishment of new vegetation. In the absence of adequate soil stabilization, stream corridors, subject to floodplain scouring, may suffer considerable winter erosion.

VEGETATION DISTURBANCE

Wetland waterway restoration, as well as floodplain wetland management, may entail a moderate amount of vegetative disturbance. Any wetland management plan must place a high priority on the preservation of existing vegetation. Particular attention should be directed toward the protection of the larger woody species. As a general management principle, the preservation of all trees should be a primary objective. Though selective removal of some smaller trees (4 in. diameter or less) will often be necessary, cutting should not be done randomly. Wetland management practices should attempt to limit vegetation disturbance to the grasses and understory shrub-scrub plant varieties.

EXCAVATION EQUIPMENT

Removal of sediment from impacted waterways usually requires excavation equipment with a maximum reach capability. Adequate reach capability is especially desirable in wetland management projects where channel resculpting may require reaching over, or around, vegetative stands, as well as the selective placement of spoil beyond a 25 ft. top of bank buffer. Wetland management equipment should also present low ground pressure to minimize soil compression and root damage to the surrounding vegetation.

BASIC PRINCIPLE OF WETLAND MANAGEMENT FOR MOSQUITO CONTROL

The Freshwater Wetlands Protection Act mandates that freshwater wetlands be identified and delineated by using 3 parameter approach (hydrology, soils and vegetation) as established by the US Environmental Protection Agency.

The Act defines a freshwater wetland as an area that is inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and does normally support, a prevalence of vegetation typically adapted for life in saturated soil conditions, commonly known as hydrophytic vegetation. This definition indicates clearly that standing surface water is not a necessary feature of freshwater wetland hydrology, since sub-surface ground water saturation will also support some hydrophytic vegetation.

The Best Management Practices for combined mosquito control and freshwater wetland management have been developed upon the principle of converting mosquito producing surface inundated wetlands to ground saturated wetlands. This management principle provides for both the elimination or reduction of mosquito producing surface water, while preserving the essential saturated wetland character and function. This management principle has little in common with traditional land reclamation practices.

The following practices are intended to serve as an alternative to continued pesticide usage for the control of mosquitoes in the State's freshwater wetlands, particularly in those wetlands being impacted by urban development.

BASIC PRACTICES FOR FRESHWATER WETLAND MOSQUITO CONTROL MANAGEMENT

Shallow Channel Restoration

The impact of accumulated sediment within the stream channels of a wetland system may require restoration of the waterway prior to management of the floodplain mosquito habitat. The removal of up to 2 ft. of channel sediment (as per NJDEP Stream Encroachment Regulations, N.J.A.C. 7:13) is generally a reasonable standard for wetland waterway management.

The primary objective of wetland channel restoration for mosquito control is to restore flow within the stream banks, while maintaining the channel water level within or near the hydric soil zone of the floodplain. The hydric soil zone depth can be reasonably estimated on the basis of soil data obtained from shallow soil borings taken near the channel.

Some creativity may be required to establish and maintain adequate water depth within a newly restored channel. This is largely due to the fluctuations in flow normally experienced by small waterways during storm events or drought conditions. Also, as small watersheds experience urbanization, these fluctuations naturally increase. Care should be taken to establish the desired channel water level during a period of normal flow so that the adjusted water level will be sustained adequately to ensure the integrity of the wetlands. A minimum channel water depth of 2 ft. is suggested for small streams in order to restore or enhance fish habitat.

The Drainage Swale

The swale is an effective wetland management tool because of its ability to accomplish the same objectives as a drainage ditch, but with a greater degree of sensitivity to its surrounding environment. Lacking defined banks, the drainage swale can be fashioned to blend into the wetland topography, while accomplishing its management functions of concentrating and removing accumulated surface water.

Freshwater wetland management swale design should be adapted to accommodate site specific conditions. However, the following swale design guidelines are recommended for typical mosquito control management sites:

1. The bottom of the swale (swale invert) should be set as high in the hydric soil zone as site grade limitations allow. In general, a swale depth of

between 6-12 in. is recommended.

2. Swales should be constructed in meandering paths, avoiding vegetative stands and trees, whenever possible.
3. All excavated material should be regraded on-site and stabilized with moisture tolerant grass varieties. Site stabilization or re-vegetation may also include planting of wetland shrubs or small trees which are indigenous to the area.

The Low Level Management Sill

Topography, hydrology, or soil conditions may make it difficult to maintain adequate ground water saturation within managed wetlands. Excessive dewatering of the hydric soil zone may occur as a result of the following conditions:

1. General lowering of ground water due to storm drainage alterations, such as storm sewer installation, etc.
2. The presence of permeable organic hydric soils (peat)
3. Wetland surface gradients exceeding 1%

A "low level sill", or weir, is a simple structure of wood, stone, or concrete which can be installed in a management swale to assist in stabilizing soil saturation. Creative combinations of shallow swales and low level management sills can be used to "fine tune" the wetland management water balance process of converting inundated wetlands to saturated wetlands.

Sill installation depth should be deep enough to restrict surface flow within the management swale and also impede movement of sub-surface flow within the wetland soil. Optimum installation depth is determined by the site soils and hydrology, as well as the desired depth of water to be retained within the swale. Some experimentation may be necessary to determine the best installation. The depth to ground water, and hydric soil zone (depth) should be determined and the sills installed to create the desired ground saturation level. A general recommendation is to install management sills so as to provide a flow barrier extending between 12 and 14 in. below the swale bottom.

Where wetland surface grade will cause even a shallow swale to excessively dewater the hydric soil, multiple management sills can be used to lower the water table in steps while maintaining soil moisture in the higher elevations of the

wetland system. A surface gradient in excess of 2% will likely require the use of tandem sills.

Wetland management sills and swales in urbanizing areas may be subject to periodic surges from stormwater culverts. Damage to the sills may occur in the form of washouts or undercutting of the sill. Wetland management systems installed in unstable organic soils, and those receiving runoff from large culverts will likely require additional stabilization protection.

BEST MANAGEMENT PRACTICES FOR MOSQUITO CONTROL IN STREAM CORRIDOR WETLANDS

Sediment choked channels artificially elevate floodplain water levels, which reduce the flood storage capacity of the floodplain, contribute to road flooding, and often generate extensive mosquito habitat.

Restoration of stream channels may, therefore, be necessary prior to management of the floodplain wetlands. It should be emphasized that the objective of mosquito control stream corridor management is not primarily to improve channel flood passage, but rather to return normal stream flow to an inbank condition in order to then convert inundated wetlands to soil saturated wetlands. The following stream corridor management practices and guidelines are to be applied with sensitivity and creativity toward that objective.

1. Minimum Vegetative Disturbance - The wetland management plan should require minimum feasible vegetation disturbance.
 - A. The initial goal is no tree cutting at all. Whenever possible, limit disturbance to grasses, and understory of woody shrubs such as Huckleberry, Honeysuckle, Alder, etc.
 - B. A compromise selective cutting of trees under 4 in. in diameter may be necessary. The management plan should designate where larger trees are proposed for removal.
 - C. Where feasible, clear one bank only. On meandering channels, alternate the bank cleared, preserving larger trees and vegetation on the outside of channel bends.
2. Sediment Containment - Place sediment screens in channel prior to restoration work.

- A. The channel volume, flow, and amounts of suspended sediments, will dictate the most effective type of sediment screen to be employed. In the presence of substantial flow, crushed stone or timbers placed upstream of the sediment screen may be necessary to absorb the thrust of channel flow. Multiple screens of various fabric textures are recommended for channels experiencing heavy sediment draft.

Hog wire or an equally rigid fence material is recommended for support of the filtering fabric. Where substantial channel flow is anticipated, additional timber supports should be added to buttress the filter frame. Numerous filter fabrics are available, but care should be taken to select one which is capable of passing the anticipated normal channel flow. Burlap has been found to be a good filter fabric for general channel usage.

- B. Sediment screens should be installed a reasonable distance downstream of excavation equipment in order to take advantage of natural settling of suspended material. This distance should vary with site conditions, and the anticipated rate of equipment progress. Sediment screens should be inspected daily, and the filter fabric replaced when clogged with sediment "fines".
- C. Where possible, utilize road culverts and bridge abutments to anchor sediment screens. Such structures should not be used without approval of the appropriate authority.
- D. The filter fabric should always be removed from its frame when significant precipitation is anticipated, or the sediment screen may cause increased flooding. Removal of the entire frame should be considered when major storm events are predicted.
3. Channel Restoration - The following procedures are recommended for restoration of waterways damaged by the impacts of urbanization or agricultural sedimentation.

Some procedures, such as sediment containment, and restabilization of disturbed areas are applicable to all management sites.

The creation or restoration of channel meanders,

however, will usually be more limited due to site conditions and regulatory restrictions. The objective of wetland channel restoration is to create a naturalistic waterway, which will then facilitate reduction of floodplain mosquito habitat with minimum floodplain wetland disturbance. Recommended channel restoration procedures include:

- A. Prior to channel restoration, determine depth of floodplain saturated soils. The various soil horizons can be determined by taking hand auger borings throughout the floodplain.
- B. Sediment removal operations should proceed downstream trapping sediments ahead of excavation.
- C. The restored channel water level should be established and maintained within the range of the floodplain hydric soil zone.
- D. Natural channel meanders should always be preserved. Further, where natural meanders have been lost as a result of channelization or heavy sedimentation, their restoration should be attempted.
- E. Where soil conditions and stream bed gradient allow, construct a pool-riffle configuration within the restored channel bed. Alternating pools and riffles within a channel bed combine the benefits of both shallow moving water and the more stable, deep-water fish habitat.

A pool-riffle pattern should not be established randomly within a restored channel, but should be integrated into the natural variations of flow velocity within stream meanders, and the straighter runs between them.

Technical assistance for channel restoration practice is available through the USNRCS, and some municipal or county engineering agencies.

- F. Regrade and stabilize excavated materials. Regraded excavated materials should be no more than 4 in. deep. Seed disturbed areas with wetland tolerant grasses.

4. Floodplain Mosquito Habitat Management - The procedures for management of productive floodplain mosquito habitat include:
 - A. Excavate shallow swales (6 to 12 in.) to convey surface water to stream channel.
 - B. Install low level sills within swales to maintain hydric soil saturation as required.
 - C. Minimize vegetative disturbance. Utilize light excavation equipment or hand labor in very sensitive areas, meandering swales around trees and dense woody vegetative stands.
 - D. Extend swales to each wetland recharge source i.e., storm drainage culverts and natural gullies.
 - E. Regrade and stabilize excavated areas with wetland tolerant grass species.

BEST MANAGEMENT PRACTICES FOR MOSQUITO CONTROL IN PALUSTRINE FRESHWATER WETLANDS

The management of mosquito habitat in Palustrine Freshwater Wetlands employs the same basic practices utilized in floodplain wetlands. However, root systems of the larger and more dense vegetation, common to forested wetlands, may impede the construction of shallow swales. Management of some forested wetlands may be accomplished more effectively by improving existing deteriorated woodland ditches or swales, and connecting them to drainage culverts discharging from developing areas. This management procedure may prove more efficient as well as less destructive to the root systems of wetland vegetation than would new swale excavation.

Retention of hydric soil saturation may be enhanced by the installation of management sills within the restored woodland ditches, or within naturally formed swales.

1. Enhancement of Existing Drainage Systems
 - A. Locate sources of water entering forested wetlands such as road culverts, farm ditches ground springs, detention basin discharges, etc.
 - B. Locate existing discharge routes.

- C. Undertake enhancement of forest discharge routes utilizing low level sills to regulate the discharge from the wetland.
 - D. Regrade and stabilize disturbed areas with moisture tolerant grass.
2. Creation of New Swale System
- A. Determine discharge point from wetland.
 - B. Utilizing hand soil borings, establish depth of hydric soil zone.
 - C. Establish lowest elevations throughout the wetland.
 - D. Excavate swale (6 - 12in. depth) from discharge point and through low elevations and extend swales to each inlet culvert or gully. Also, meander swales around large trees or woody bushes and shrubs.
 - E. Install low level sills to regulate wetlands within the swales to enhance soil saturation.
 - F. Regrade disturbed soil and stabilize with wetland tolerant grass species.

BEST MANAGEMENT PRACTICES FOR MOSQUITO CONTROL IN ISOLATED FRESHWATER WETLANDS

An isolated wetland is one which has no known drainage outlet to a stream or another nearby wetland area. It may be desirable to manage an isolated wetland due to the presence of mosquito habitat which impacts nearby residential areas. The "adjusted resource value" of an isolated wetland in, or near, a developing area may be assessed on the basis of the following criteria: the area of wetland, the quality of the wetland, and the extend of the wetland's mosquito impact upon area residents.

1. Standard Surface Culvert Outlet

- A. Provide culvert outlet through confining high ground, roadway, utility easement, etc.
- B. Establish culvert outlet invert 12-14 in. below the wetland surface, using the hydric

soil zone depth as a guide,

- C. Excavate shallow tributary swales to each storm drainage culvert recharging the wetlands in order to relieve existing standing surface water,
 - D. Regrade and stabilize disturbed areas.
2. Infiltration Enhancement (Perched System) - If the ground water level is low enough infiltration from an isolated freshwater wetland may be enhanced by lateral outlets to pervious upland soils outside of the wetland soil boundary, or by vertical outlets to subsoils.
3. Lateral Drainage:
- A. use hand borings to establish depth of hydric soil and depth to ground water.
 - B. provide controlled outlet to permeable subsoil.
 - C. excavate shallow swales to wetland recharge culverts.
 - D. restabilize disturbed areas.
4. Vertical Drainage:
- A hydraulic connection between a confirmed wetland and underlying pervious soils may be established by installing vertical drainage pipes through the hydric soil strata. The upper end of the pipe should be used to maintain the desired ground water saturation level within the wetland. Care should be taken to "repack" the impervious soil around the vertical discharge pipe in order to prevent excessive dewatering of wetland.

BEST MANAGEMENT PRACTICES FOR MOSQUITO CONTROL IN CONSTRUCTION DISTURBED FRESHWATER WETLANDS

The degrading impacts of construction on wetlands encompass a broad spectrum ranging from the subtle concentration of heavy metals and hydrocarbons, to the obvious sediment loading or filling of streams and waterways. Mosquito control agencies have generally reacted in a "janitorial

role" to clear sediment and debris from waterways, thus making possible remedial mosquito source reduction within stream corridors and wetlands. Though remedial mosquito control is necessary where wetlands have already been impacted, a preventative approach to mosquito control has been demonstrated to be an effective abatement strategy for areas where the state's wetlands are under the stress of urbanization. Consequently, Part 2 of this section is considerably more detailed in order to provide guidance in the development and implementation of a preventative mosquito control program for freshwater wetlands.

1. Post Construction Management (Remedial Management)

Recommended procedures for wetland management for mosquito control in construction impacted areas:

A. Identify the sources of the following wetland degradation agents such as:

sedimentation
"filling"
site development
linear development
road bed construction
sanitary sewer, utility, installations
urban quality stormwater runoff
septic leachate
other point or non-point sources

B. Develop a management plan which includes a sketch plan of wetland area. (Sketch details onto municipal tax maps, scale 1" = 100' or 200' and a brief description of, wetland impacts, existing mosquito problems, and proposed management practices.

C. Implement the appropriate wetland management practices to reduce the mosquito habitat.

2. Pre-construction Review (Preventative Management)

The effective management of freshwater wetlands for mosquito control begins with minimizing adverse wetland impacts before they occur. Experience has shown that properly located, designed, constructed and maintained stormwater management facilities help to reduce the degrading impacts upon wetlands adjoining developed areas.

It should be noted that indiscriminate discharge of urban storm runoff to wetland ecosystems is common practice today. And, the continuing discharge of contaminant-laden stormwater into

freshwater wetlands is having a significant, immediate, as well as cumulative, impact upon mosquito production in urbanizing areas. In view of this situation a pre-construction, site plan review procedure, should logically be a part of an integrated mosquito control program in New Jersey.

- A. Sub-division and Site Plan Review Program - when correctly, and consistently implemented, a site plan review program is very effective mosquito control procedure. In New Jersey, mosquito control agencies do not possess direct land use regulatory authority for control of stormwater management practices on development sites. However, **NJSA 26:9** grants authority to county mosquito commissions to perform all acts which in their opinion will exterminate mosquitoes or which will tend to exterminate them. Mosquito commissions are also endowed with the same authority as municipal boards of health in matters relative to mosquito control. However, mosquito control agencies can also effectively utilize the authority of county and municipal planning and engineering agencies by joining a site plan review team.

Mosquito control agencies possess unique perspective, as agencies which regularly respond to the immediate and cumulative public health impacts of construction stormwater management practices. When able to articulate this perspective, mosquito control agencies can contribute valuable, fresh insights to planners and engineers. More quality mosquito control can often be accomplished with one site plan review report than by months of expensive remedial field work. Consequently, the disciplined review of stormwater management systems on proposed development sites is a recommended best management practice.

- B. Establishing A Review Program - The following procedure is recommended for initiating and administering a site development plan review program for mosquito control.

- (1) Inform the county planning agency of the mosquito agency's desire to provide advisory input on the mosquito-related impacts of

proposed stormwater management systems. This initial communication should emphasize that the objective of this advisory input is to enable the mosquito control agency to more effectively protect the health and comfort of the public, and protect our water resources. A review program can be initiated at the municipal level rather than with the county. A county level program is preferable, however, since the county planning agency's jurisdiction boundaries coincide with those of the mosquito control agency, and most major development plans are normally forwarded to the county from its municipalities. Municipal relationships may naturally develop as the county reports reflect mosquito control agency comments, which will be of interest to local environmental commissions or engineers.

- (2) Request a set of preliminary site development plans for each proposed development. These plans contain the proposed stormwater management information necessary for mosquito control agency review.
- (3) A written site review report should be forwarded to the county planning agency identifying existing on-site mosquito problems, mosquito problems on adjoining property and potential mosquito problems generated by the proposed stormwater management plan (SWMP) or site grading.
- (4) The review report should suggest modifications to the proposed SWMP which will either reduce or eliminate the potential mosquito problem.
- (5) Provide the county planning board site plan review staff with a county map identifying areas of major existing mosquito problems which will be sensitive to development impacts. Major areas of freshwater wetlands and deteriorated stream corridors should be designated as "mosquito sensitive".

C. Site Plan Review Report - Site plan review for mosquito control should concentrate upon proposed stormwater management practices and structures, and involve other aspects of the site plan only as they may affect mosquito control.

The site plan review report should evaluate the following:

- (1) On-site and adjoining waterways
their existing condition
potential impacts of any proposed alteration
- (2) On-site floodplains,
existing mosquito habitat
presence of FWWL
potential impacts on mosquito production
by stormwater discharges or filling
- (3) Area topography
potential impounding of surface runoff
upgrade of site
potential inundation of downgrade areas by
site discharge
- (4) Stormwater Management Facilities
Basin design
potential in-basin mosquito habitat
provision for maintenance

Basin location
relative to ground water table
subject to excessive sedimentation
quality of incoming water

Relative to FWWL's
potential dewatering of FWWL
direct discharge to FWWL (contaminant
impacts)
water level fluctuations in wetlands
general FWWL damage

Discharge of basin
adequate rate to prevent mosquito habitat
adequate rate to allow maintenance
outlet protection for small orifice i.e.,
trash rack
- (5) Freshwater Wetlands (on-site and off site)
existing mosquito problem
stormwater impacts upon mosquito production

BEST MANAGEMENT PRACTICES FOR MOSQUITO CONTROL IN STORMWATER FACILITIES

In the absence of design and maintenance standards, many stormwater management facilities (SWMF) throughout the State have developed into freshwater wetlands. Many such basins are completely unmaintainable, being overgrown with aquatic vegetation, and often recharged by contaminant-laden urban or industrial quality storm runoff.

These basins often provide ideal habitat for mosquitoes. Mosquito productive stormwater management facilities (SWMF) are placing a continually increasing burden upon county mosquito control agencies. New construction, in the absence of regional stormwater management planning, will require the construction of additional on-site facilities.

A New Jersey Department of Environmental Protection funded study of the social, and public health impacts of existing New Jersey Stormwater Management facilities was completed in 1988. Standards for facility design, construction, and maintenance, are now available to developers, engineers and planning agencies. These standards provide guidance for the construction and maintenance of new facilities and the upgrading of existing problem basins.

There are three types of stormwater facilities:

1. Detention basins, designed to be dry between storm events;
2. Retention basins or permanent ponds; and
3. Recharge basins, designed to percolate storm runoff into underlying soils.

To function efficiently, a stormwater management facility must:

1. Be correctly designed for the intended function.
2. Be correctly sited relative to the area hydrology and soil types.
3. Be constructed according to the engineering plan.
4. Be adequately maintained for continued functioning.

Freshwater wetland mosquito habitat will seldom develop in a facility which has been correctly designed, situated, constructed, and maintained. However, many facilities are

mosquito problems, placing an increasing burden upon county mosquito control agencies' larvicide programs. Major basin modifications may be necessary to eliminate standing water. In many facilities minor grading or installation of low flow channels may remedy the condition.

1. Mosquito-producing stormwater facilities

A. Evaluate public need for mosquito control

- (1) Basin location
 - residential area
 - commercial area
 - industrial area
- (2) Mosquito species produced
- (3) Public opinion regarding the problem basin
- (4) Assess existing temporary control procedures: i.e. larviciding frequency, access to basin and effectiveness of pesticide applications, and

B. Determine cause of basin failure: i.e., failure to completely discharge, or discharge too slowly, aquatic vegetation, overgrowth, etc.

(1) Design

- inadequate floor gradient
- outlet elevation too high
- no inlet stabilization
- no trash rack protection

(2) Siting

- high ground water table
- receding ground water table
- excessive sedimentation
- basin floor "sealed" (recharge basin)
- heavy pollutant loading (retention or recharge basin)
- off-site receiving system inadequate
- inadequate recharge

(3) Construction

- basin floor grading
- depressions, inadequate gradient in basin floor
- incorrect low flow channel grade

basin discharge elevation lower than
receiving stream
basin water depth too shallow
soil recharge enhancement needed

(4) Maintenance

excessive sedimentation
sealed percolation basin floor
heavy vegetation (retention basin)
heavy frost damage to low flow channel
or outlet debris accumulation
vandalism

C. Select mosquito abatement option

- (1) Continue pesticide applications
- (2) Evaluate feasibility of facility
modification

D. Establish basin ownership

- (1) Public ownership-municipal
- (2) Private ownership-commercial, industrial
- (3) Homeowners association-condominiums,
apartments
- (4) Public agency ownership-New Jersey
Department of Transportation, (highway
basins)

E. Research existing maintenance contracts,
agreements, bonds or escrow accounts for
potential management funding.

2. Stormwater Facility Basin Modification

Mosquito control agencies do not normally perform regular periodic maintenance of stormwater facilities. However, modification of existing mosquito producing facilities may be a practical option to continuing pesticide control measures, particularly where basin conditions, or location, limit the effectiveness of the larvicide effort.

Basin modification plans should be developed in cooperation with other public agencies such as the municipal engineers office and the soil conservation district. Within a cooperative plan, however, the focus must be kept upon mosquito abatement as the priority objective.

The New Jersey Wetlands Protection Act (Section 23:c.8) provides that the maintenance and repair of stormwater management facilities, which contain freshwater wetlands, shall be authorized by a General Wetland Permit.

3. Stormwater Facility Management Procedures

A. Remove impediments such as sediment and debris to restore complete basin discharge flow.

B. Reconstruct basin floor

(1) establish low flow swale from inlets to discharge point.

(2) stabilize low flow channel with crushed stone or reinforced concrete Min. 1-2% slope (grassed 3)

(3) establish lateral floor gradient 1-2% from toe of side slope to low flow channel.

(4) provide stabilization at inlets with crushed stone and stabilize basin floor with grass seeding.

C. Where basin retains shallow water due to a high water table, there are two remedial options.

(1) site conditions allowing, raise floor of basin to at least one foot above ground water elevation and modify facility to function as dry basin.

(2) deepen basin

(i) to minimum 5 foot permanent water depth.

(ii) establish predaceous fish population

D. Where recharge basin floor has "sealed"

(1) "scarify" basin floor to restore percolation to subsoil

(2) clean or replace seepage pits

(3) install recharge enhancement trenching in graded floor

(4) fill trench with clean stone, replace vegetative stabilization.

E. In residential areas, where off-site basin discharge is possible, install small diameter outlet pipe with gate valve control.

MITIGATION WETLANDS

With recognition that some freshwater wetland loss may accompany land development, the Freshwater Wetlands Protection Act requires the creation, restoration or enhancement of wetlands of equal ecological value. Such compensatory wetlands are created to mitigate or reduce the ecological impact of freshwater wetland loss within the system.

Mitigation wetlands are of special concern to mosquito control agencies for three reasons:

1. The art of freshwater wetland creation is a relatively new practice, and some developers are unfamiliar with correct procedures.
2. FWWL replacement obligations may be imposed on a 2 to 1, or 3 to 1 ratio. That is, two acres of man-made wetland are required to compensate the one are of natural wetland lost. Under pressure satisfy mitigation obligations, land developers may construct new wetlands incorrectly, resulting in new mosquito habitat near residential areas.
3. A balanced freshwater wetland ecosystem, which encourages mosquito predaceous species, may take years to become established.

These factors indicate that there is presently a high potential for mosquito problems in man-made wetlands. A first step toward addressing this potential problem requires that any proposed new wetland construction in or near to residential areas should be reviewed carefully by local public health and mosquito control agencies. In order to encourage and assist such review, the Freshwater Wetlands Protection Act Rules requires that copies of all individual Freshwater and Open Water Fill Permit applications be forwarded to the county mosquito control agency.

The N.J. Department of Environmental Protection's Land Use Regulation Program's Application Support Unit also forwards copies of permit applications to the Office of Mosquito Control Coordination for its review and comments.

The county mosquito control agency in cooperation with the municipal or county health department should:

1. Establish a file of proposed mitigation wetland activities within their jurisdiction.
2. Request adequate time to review mitigation construction plan proposals prior to permit or site plan approval.
3. Become familiar with basic mitigation techniques, utilizing available professional assistance if needed.
4. Develop in-house capability to evaluate wetland construction plans, and aggressively request modifications which, in its opinion, will prevent the creation mosquito habitat.

Interim mitigation wetland research findings are released periodically by the U.S. Environmental Protection Agency's Environmental Research Laboratory. For current information, and to be placed on the program mailing list, contact:

Wetland Research Program
Environmental Research Laboratory
200 S.W. 35th Street
Corvallis, Oregon 97333
Phone: (541) 754-4600

In the absence of detailed mitigation guidelines, the following design criteria are recommended to minimize potential mosquito production in manmade FWWL wetland creation projects:

1. Proposed wetland should have adequate surface gradient to prevent standing surface after accumulations. A 2% grade is recommended.
2. Provide diversity within the wetlands by creating or improving an open water receiving area, such as a pond or stream. The open water should have adequate depth to support predaceous fish species and shallows (1 ft. \pm) to encourage waterfowl usage.
3. Utilize wetland grass species and shrub plantings to stabilize new wetland surface.

APPENDIX 1

DEFINITIONS

Channel Restoration - removal of sediment and debris from a waterway in order to return normal stream flow to within the banks. Preservation of existing channel meandering alignments is recommended.

Channelization - refers to the straightening, deepening, and enlarging of a waterway to allow increased flood water passage. Channelization may also include creation of a trapezoidal channel section stabilized by concrete.

Cumulative Adverse Impacts - means the destructive effects resulting from the repetition of minor damage.

Delineated Wetland (FWWL) - means the destructive effects resulting from the repetition of minor damage.

Endangered Species - those species who prospect for survival in the state are in immediate danger because of a loss or change of habitat, over exploitation, predation, competition or disease. Immediate assistance is needed to prevent extinction.

FW-1 Waters - means those fresh waters that originate in and are wholly within Federal or State Parks, forests, fish and wildlife lands, and other special holdings, that are to be maintained in their natural state of quality (set aside for posterity, and not subjected to any wastewater discharges of human origin), as designated in the Department's Surface Water Quality Standards, N.J.A.C. 7:9-4.

FWWL - shall mean protected freshwater wetlands.

Hydric Soil - a soil that in its undrained condition is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation.

Hydric Soil Zone - the depth of hydric, or wetland soil.

Hydrophytic Vegetation - plants adapted to growth and reproduction under periodically saturated root zone conditions during at least a portion of the growing season.

Infiltration - means the movement of water from the land surface into underlying soils.

Mitigation Wetland - freshwater wetland which is either created, restored, enhanced or deeded to public ownership, as compensation for wetland destroyed.

Saturated Soil - soil lacking free oxygen due to sustained surface inundation, or ground water saturation at or near the ground surface.

Stormwater Contaminants - refers to the dissolved or suspended substances commonly present in stormwater runoff from urbanized or active agricultural areas. Typical urban source contaminants include hydrocarbons in various forms, road salts, pesticides, and heavy metals. Agricultural source contaminants include pesticides, animal waste and sediment.

Stream Corridor - the channel, banks, and floodplain of a flowing stream.

SWMF - shall mean stormwater management facility. Usually reference is to a detention basin.

The Act - shall mean the New Jersey Freshwater Wetlands Protection Act of 1987 (N.J.A.C. 13:9b-1 et seq.).

The Department - shall mean the New Jersey Department of Environmental Protection and Energy.

Threaten Species - those species identified pursuant to the Endangered and Nongame Species Conservation Act, N.J.S.A. 23:2A-1 et seq., or those identified pursuant to the Endangered Species Act of 1973, 16 U.S.C. 1531 et al.

Urban Stormwater Runoff - refers to surface drainage water from the paved streets, driveways, parking lots and commercial sites within developed areas.

Wetland Hydrologic Regimen - refers to the movement of surface or ground water into, within, or from a wetland area.

APPENDIX 2

NEW JERSEY PLANTS UNDER REVIEW FOR FEDERAL LISTING AS ENDANGERED SPECIES**

<u>Common Name</u>	<u>Scientific Name</u>
Sensitive Joint Vetch	<i>Aeschynomene virginica</i>
Sea-beach Pigweed	<i>Amaranthus pumilus</i>
Sand Grass	<i>Calamovilfa brevipilis</i>
Long's Bitter Cress	<i>Cardamine longii</i>
Barrett's Sedge	<i>Carex barratii</i>
Variable Sedge	<i>Carex polymorpha</i>
Parker's Pipewort	<i>Eriocaulon parkeri</i>
Pine Barrens Boneset	<i>Eupatorium resinosum</i>
Darlington's Spurge	<i>Eurphorbia purpurea</i>
Pine Barren Gentian	<i>Gentiana autumnalis</i>
Eaton's Quillwort	<i>Isoetes eatonii</i>
New Jersey Rush	<i>Juncus caesariensis</i>
Boykin's Lobelia	<i>Lobelia boykinii</i>
Nuttall's Micranthemum	<i>Micranthemum micranthemoides</i>
Torrey's Muhly	<i>Muhlenbergia torreyana</i>
Bog Asphodel	<i>Narthecium americanum</i>
Hirst's Panic Grass	<i>Panicum hirstii</i>
Jacob's Ladder	<i>Pelemonium vani-bruntiae</i>
Awed Meadow Beauty	<i>Rhexia aristosa</i>
Knieskern's Beaked Rush	<i>Rynchospora knieskernii</i>
Curly Grass Fern	<i>Schizaea pusilla</i>
Chaffseed	<i>Schwalbea americana</i>
Long's Bulrush	<i>Scirpus lingii</i>
Spreading Globe-flower	<i>Trollius laxus laxus</i>

FEDERALLY THREATENED SPECIES*

Swamp Pink	<i>Helonias bullata</i>
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*The Swamp Pink was listed as a federally threatened species on September 9, 1988.

**Further information about rare plants is available through the Office of Natural Lands Management, N.J. Department of Environmental Protection and Energy, CN 404, Trenton, NJ 08625.

APPENDIX 3

ENDANGERED/THREATENED FAUNA OF NEW JERSEY

The following species are listed as endangered/
threatened on the New Jersey State list as of June 3, 1991.

AMPHIBIANS

Endangered

Tremblay's Salamander, *Ambystoma tremblayi*
Blue-spotted Salamander, *Ambystoma laterale*
Eastern Tiger Salamander, *Ambystoma t. tigrinum*
Pine Barrens Treefrog, *Hyla andersonii*
Southern Gray Treefrog, *Hyla chrysocelis*

Threatened

Long-tailed Salamander, *Eurycea longicauda*
Eastern Mud Salamander, *Pseudotriton montanus*

REPTILES

Endangered

Bog Turtle, *Clemmys muhlenbergi*
Atlantic Hawksbill, *Eretmochelys imbricata***
Atlantic Loggerhead, *Caretta caretta***
Atlantic Ridley, *Lepidochelys kempi***
Atlantic Leatherback, *Dermochelys coriacea***
Corn Snake, *Elaphe g. guttata*
Timber Rattlesnake, *Crotalus h. horridus*

Threatened

Wood Turtle, *Clemmys insculpta*
Atlantic Green Turtle, *Chelonia mydas***
Northern Pine Snake, *Pituophis m. melanoleucus*

BIRDS

Endangered

Pied-billed Grebe, **Podilymbus podiceps*
Bald Eagle, *Haliaeetus leucocephalus***
Northern Harrier, **Circus cyaneus*
Cooper's Hawk, *Accipiter cooperii*
Red-shouldered Hawk, *Buteo lineatus* (breeding)
Peregrine Falcon, *Falco peregrinus***
Piping Plover, *Charadrius melodus***
Upland Sandpiper, *Bartramia longicauda*
Roseate Tern, *Sterna dougallii*
Least Tern, *Sterna antillarum*
Black Skimmer, *Rynchops niger*
Short-eared Owl, **Asio flammeus*
Sedge Wren, *Cistothorus platensis*
Loggerhead Shrike, *Lanius ludovicianus*
Vesper Sparrow, *Pooecetes gramineus*
Henslow's Sparrow, *Ammodramus henslowii*

Threatened

American Bittern*, *Botaurus lentiginos*
Great Blue Heron*, *Ardea herodias*
Little Blue Heron, *Egretta caerulea**
Yellow-crowned Night Heron, *Nyctanassa violaceus*
Osprey, *Pandion haliaetus*
Northern Goshawk, *Accipiter gentilis*
Red-shouldered Hawk, *Buteo lineatus* (Non-breeding)
Black Rail, *Laterallus jamaicensis*
Long-eared Owl, *Asio otus*
Barred Owl, *Strix varia*
Red-headed Woodpecker, *Melanerpes erythrocephalus*
Cliff Swallow, **Hirundo pyrrhonota*
Savannah Sparrow, *Passerculus sandwichensis*
Ipswich Sparrow, *Passerculus sandwichensis princeps*
Grasshopper Sparrow, *Ammodramus savannarum*
Bobolink, *Dolichonyx oryzivorus*

FISH

Endangered

Shortnose Sturgeon, *Acipenser brevirostrum***

Threatened

Brook Trout, *Salvelinus fontinalis*

MAMMALS

Endangered

Bobcat, *Lynx rufus*
Eastern Woodrat, *Neotoma floridana*
Sperm Whale, *Physeter macrocephalus***
Fin Whale, *Balaenoptera physalus***
Sei Whale, *Balaenoptera borealis***
Blue Whale, *Balaenoptera musculus***
Humpback Whale, *Megaptera novaeangliae***
Black Right Whale, *Balaena glacialis***

INVERTEBRATES

Threatened

Mitchell's Satyr (butterfly), *Neonympha m. mitchellii***
Northeastern Beach Tiger Beetle, *Cicindela d. dorsalis*
American Burying Beetle, *Nicrophorus americanus***
Dwarf Wedge Mussel, *Alasmodonta heterodon***

* Only breeding population considered endangered or threatened

**Federally endangered or threatened

APPENDIX 4

FRESHWATER WETLAND PLANT TYPES OCCURRING IN NEW JERSEY

1. Wetland trees

Red Maple (*Acer rubrum*)
Willows (*Salix* spp.)
Black Spruce (*Picea marina*)
Swamp White Oak (*Quercus bicolor*)
Red Ash (*Fraxinus pennsylvanica*)
Black Ash (*Fraxinus nigra*)
Silver Maple (*Acer saccharinum*)
American Elm (*Ulmus americana*)
Larch (*Larix laricina*)
Black Gum (*Nyssa sylvatica*)
White Cedar (*Chamaecyparis thyoides*)

2. Wetland shrubs

Alder (*Alnus* spp.)
Buttonbush (*Cephalanthus occidentalis*)
Bog Rosemary (*Andromeda glaucophylla*)
Dogwoods (*Cornus*, spp.)
Leatherleaf (*Chamaedaphne calyculata*)

3. Emergent vegetation

Cattails (*Typha* spp.)
Pickerelweed (*Pontederia cordata*)
Bulrushes (*Scirpus* spp.)
Arrow Arum (*Peltandra virginica*)
Arrowheads (*Sagittaria* spp.)
Reed (*Phragmites communis*)
Wild Rice (*Zizania aquatica*)
Bur-reeds (*Sparganium* spp.)
Purple loosestrife (*Lythrum salicaria*)
Swamp-loosestrife (*Decodon verticillatus*)
Water plantain (*Alisma plantago-aquatica*)

4. Rooted, floating leaved vegetation

Water-lily (*Nymphaea odorata*)
Water shield (*Brasenia schreberi*)
Spatterdock (*Najas* spp.)

5. Free-floating vegetation

Duckweed (*Lemna spp.*)
Big duckweed (*Spirodela polyrhizia*)
Water meal (*Wolffia spp.*)

6. Wet meadow vegetation

Sedges (*Carex spp.*)
Rushes (*Juncus spp.*)
Cattails (*Typha spp.*)
Rice cut-grass (*Leersia oryzoides*)
Reed Canary Grass (*Phalaris arundinacea*)
Swamp loosestrife (*Decodon verticillatus*)

7. Bog mat vegetation

Sphagnum mosses (*Sphagnum spp.*)
Bog rosemary (*Andromeda glaucophylla*)
Leatherleaf (*Chamedaphne calyculata*)
Pitcher plant (*Sarracenia purpurea*)
Cranberries (*Vaccinium macro carpon*)

8. Submerged vegetation

Pondweeds (*Potamogeton spp.*)
Naiads (*Najas spp.*)
Bladderworts (*Utricularia spp.*)
Wild celery (*Vallisneria americana*)
Coontail (*Ceratophyllum demersum*)
Water milfoils (*Myriophyllum spp.*)

APPENDIX 5

GRASSES FOR CONSERVATION IN THE NORTHEAST USDA NATURAL RESOURCES CONSERVATION SERVICE

1. Tall Fescue (*Festuca arundinacea*, Schreb.)

(Kentucky 31 and Alta)

A robust, long-lived, deep-rooted, bunchy grass often with short rhizomes. Useful for stabilization of waterways, slopes, banks, fills and spoils. Foliage is eaten by geese, deer, and cottontailed rabbits. The plant also provides nesting and fall winter cover for birds.

2. Reed Canarygrass (*Phalaris arundinacea* L.)

An excellent grass for stabilizing waterways, healing and controlling gullies, and protecting shorelines of ponds and reservoirs from wave action. Reed canarygrass is a long-lived clumpy perennial with coarse rhizomes.

3. Switchgrass (*Panicum virgatum*, L.)

Switchgrass is a valuable soil stabilization plant on strip-mine spoil. Switchgrass provides excellent nesting and fall winter cover, for pheasants, quail, and rabbits. It is sod forming, stiff stalked, and leafy.

4. Perennial Ryegrass (*Lolium perenne* L.)

A short-lived perennial, this bunchy grass grows from 1 to 2 feet tall. It is used extensively for erosion control, soil improvement, and cover crops.

5. Orchard Grass

Common variety in the Northeastern States, is long-lived with dense, bunch type tufts. Used for soil improvements, silage, and erosion control.

6. Red Fescue (*Festuca rubra* L.)

An excellent soil binder, this variety is used extensively for stabilizing waterways, slopes, banks, cuts, and fills. Occurs in the creeping and bunch types, with the creeping red fescue spreading by short underground stems that form a tight, uniform sod. It is drought resistant, and adapts to both sandy and acid

soils. Creeping Red Fescue has been an outstanding soil finder in poorly drained areas.

7. Redtop (*Arctostaphylos alba* L.)

A wide spread grass throughout the Northeast, this soil binder will grow under a wide variety of soil and moisture conditions. It seems no other grass will tolerate so great a variety of conditions as this grass.

8. Annual Lespedeza (*Lespedeza striata*)

Another soil tolerant specie, this grass and its varieties will grow in soil textures ranging from sands to clays, and at fertility levels from low to high. Used for erosion control and general soil improvement, the Lespedezas also provide wildlife food.

9. Kentucky Bluegrass (*Poa pratensis* L.)

This long-lived perennial grass forms a dense sod, and is used extensively for lawns, playgrounds, etc. It is also used for stabilizing waterways, slopes, banks, and fills. It is the most common pasture grass in the Northeast, providing food for ruffed grouse, turkeys, deer, and rabbits.

APPENDIX 6

FRESHWATER MANAGEMENT PONDS

The retention of adequate soil saturation within managed wetlands may prove difficult even with the use of management sills. Ponds (5 ft. + in depth) with controlled outlet elevations may prove useful for stabilizing wetland ground water elevations in adjoining wetlands.

The employment of open water ponding within wetlands has not been designated a primary best management practice because of the extensive land disturbance normally associated with pond excavation. Additionally, some regulatory agencies view the creation of new ponds in wetlands as a loss of wetland values and function. Nevertheless, the use of ponding to increase wetland habitat diversity should not be abandoned.

The creative use of open ponds within a wetland management plan is particularly appropriate in urbanizing areas where:

1. Pond excavation will require negligible wetland disturbance beyond the pond perimeter.
2. Soil and ground water conditions indicate that the pond water will help to maintain hydric soil saturation.
3. The pond will perform a "buffering" function upon urban stormwater runoff prior to its release into a wetland or waterway.

The most significant impact characterizing such "interface" areas is the repeated discharge of contaminant-laden stormwater into the wetland environment. Among the positive features of wetland management ponds near the wetland-upland boundary are:

1. Ready access to the upland would allow pond excavation and spoil haulage with little or no wetland disturbance beyond the pond edge and stormwater discharge culverts.
2. The pond can be situated on-line with shallow wetland management swales and stormwater discharge culverts.
3. The swales and pond are situated so as to absorb and dilute urban stormwater runoff contaminants prior to their entering waterways or wetlands.

Pond Design

A portion of the proposed pond should be shallow (approx. 1 ft.) in order to create an area of emergent wetland and to provide habitat for wading birds and wildfowl. The larger portion of the pond should be least 5 feet deep, however, in order to create stable fish habitat, and a volume of water capable of "buffering" the adverse impacts of urban stormwater contaminants.

Wetland ponds should be flexibly and creatively designed to affect water quality enhancement, while blending into the site vegetation and topography. The filtering or biochemical buffering capacity of an urban wetland pond is largely governed by its volume and the quality of water it receives from the upland. The following pond design and site parameters are suggested:

1. Pond size - approximately 1/8 acre or larger.
(50' x 100")
2. Water depth - 4-5 ft. minimum, main body;
1+ ft. emergent vegetation area
3. Minimum tree removal
4. Retain buffer areas
5. Restore spoil haulage route and stabilize
6. Provide predaceous fish stocking within pond.

A properly designed and sited wetland "buffer" pond will also provide:


1. Increased adequate habitat diversity
2. Waterfowl resting or habitat area
3. Recreation use

APPENDIX 7
State of New Jersey


NOTE: If you are applying for a CAFRA Permit by Rule, you need to complete items 1 thru 6 and the signature area on page 3

- FOR OFFICIAL USE ONLY**

A horizontal ruler with a black border. It has major tick marks every 1 cm, labeled from 0 to 10. There are also minor tick marks every 1 mm. The ruler is placed horizontally across the page.

[illegible]

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6. Application(s) for: (Please check all that apply)

Stream Encroachment:	Permit _____	Waiver _____
CAFRA:	Individual Permit _____	General Permit _____
	Exemption Request _____	Permit by Rule _____
Freshwater Wetlands:	Individual Permit _____	General Permit _____
	Transition Area Waiver _____	Letter of Interpretation _____
	Exemption Request _____	Open Water Fill Permit _____
Waterfront Development:	Residential _____	Commercial _____
Upland Waterfront Development:	Residential _____	Commercial _____
Water Quality Certificate	_____	Tidal Wetlands (1970) _____
Federal Consistency Determination	_____	Jurisdictional Determination _____
Permit Modification (specify)	_____	
Other (specify)	_____	

7. Indicate below if any of the following approvals, denials or certifications were received for the project site or required for the proposed project:

- In Column A, indicate application status: (*P for* - pending, *A for* - approved, *D for* - denied, *T for* - to be applied for, or *O for* - other (explain other)).
- In Column B, indicate application, permit, or docket number.

	A	B		A	B
CAFRA Permit	_____	_____	Stream Encroachment Permit	_____	_____
CAFRA Permit Modification	_____	_____	Stream Encroachment Waiver	_____	_____
CAFRA Exemption	_____	_____	Stream Encroachment Permit Modification	_____	_____
Waterfront Development Permit	_____	_____	Water Quality Certificate	_____	_____
Tidal Wetlands (1970) Permit	_____	_____	Tidelands (Riparian) Conveyance	_____	_____
Statewide General Freshwater Wetlands Permit	_____	_____	Dam Construction or Repair Permit	_____	_____
Freshwater Wetlands Letter of Interpretation	_____	_____	Pinelands Certificate of Filing	_____	_____
Freshwater Wetlands Transition Area Waiver	_____	_____	D & R Canal Commission Certificate	_____	_____
Individual Freshwater Wetlands Permit	_____	_____	Federal Permits (Specify)	_____	_____

APPLICANT SIGNATURE

I certify under penalty of law that the information provided in this document is true and accurate. I am aware there are significant civil and criminal penalties for submitting false or inaccurate information. (If corporate entity, print/type the name and title of person signing on behalf of the corporate entity.)

Signature of Applicant/Owner

Signature of Applicant/Owner

Date

Date

.....
A. **PROPERTY OWNER'S CERTIFICATION***

I hereby certify that the undersigned is the owner of the property upon which the proposed work is to be done. This endorsement is certification that the owner grants permission for the conduct of the proposed activity. In addition, I hereby give unconditional written consent to allow access to the site by representatives or agents of the Department for the purpose of conducting a site inspection or survey of the project site.

In addition, the undersigned property owner hereby certifies:

1. Whether any work is to be done within an easement - Yes _____ No _____
2. Whether any part of the entire project (eg., pipeline, roadway, cable, transmission line, structure, etc.) will be located within property belonging to the State of New Jersey - Yes ___ No _____

*Type or Print Name and Address of Owner,
if different from item 1 on Page 1*

Date

Signature of Property Owner

B. APPLICANT'S AGENT

I _____, the Applicant/Owner, authorize to act as my agent/representative in matters pertaining to my application the following person:

Name _____

Occupation/Profession _____

(Signature of Applicant/Owner)

AGENT'S CERTIFICATION

Sworn before me

this _____ day of
_____ 19 _____

I agree to serve as agent for the above-mentioned applica

Notary Public

(Signature of Agent)

C. STATEMENT OF PREPARER OF PLANS, SPECIFICATIONS, SURVEYOR'S OR ENGINEER'S REPORT

I hereby certify that the plans, specifications and engineer's report, if any, applicable to this project comply with current rules and regulations of the New Jersey Department of Environmental Protection with the exception noted.

Signature

Type: Name and Date

Position, Name of Firm

APPENDIX F:

Completed Questionnaires

*The following appendix contains pages that are not numbered consecutively. It should also be noted that not every participating vector control agency completed all six pages of the survey, thus some pages from individual responses will appear to be missing.

APPENDIX E:

**New Jersey Department of Environmental
Protection, State Mosquito Control Commission**

***"Best Management Practices for Mosquito Control and
Freshwater Wetlands Management"***

APPENDIX F:

Completed Questionnaires

*The following appendix contains pages that are not numbered consecutively. It should also be noted that not every participating vector control agency completed all six pages of the survey, thus some pages from individual responses will appear to be missing.